SPRING
PRINTEMPS
71

Science tames the Leafcutter bee.
See story page 3.

La domestication de la mégachile.
Voir page 3.

CANADA AGRICULTURE

CANADA AGRICULTURE

VOLUME 16 SPRING 1971 NO. 2
VOLUME 16 PRINTEMPS 1971 Nº 2

JOURNAL OF THE CANADA DEPARTMENT OF AGRICULTURE—OTTAWA
REVUE DU MINISTÈRE DE L'AGRICULTURE DU CANADA—OTTAWA

MINISTER, HON. H. A. OLSON, MINISTRE DEPUTY MINISTER, S. B. WILLIAMS, SOUS-MINISTRE

CANADA AGRICULTURE is published quarterly to inform extension workers and agribusinessmen of developments in research and other federal agricultural responsibilities.

Contributors may submit articles in either English or French to the Secretary, Editorial Board, Information Division, Canada Department of Agriculture, Ottawa.

La revue trimestrielle *CANADA AGRICULTURE* renseigne les vulgarisateurs et représentants du négoce agricole sur les développements de la recherche et des autres services agricoles du gouvernement fédéral.

Les articles en anglais ou en français doivent être adressés au secrétaire du Comité de rédaction, Division de l'information, ministère de l'Agriculture du Canada, Ottawa.

SCIENCE TAMES THE LEAFCUTTER

D.W. MACDONALD

Des années d'études ardues sur le mode de vie d'une abeille importée, ont permis à un scientifique du ministère fédéral de l'Agriculture de la domestiquer et de lui faire accomplir un service essentiel de pollinisation sur plusieurs centaines d'acres de luzerne au Canada.

During World War II, Soren Peterson got into alfalfa seed production in the Tilley area of the Eastern Irrigation District of southern Alberta. He enjoyed the boom years just after the war when Canada was supplying forage seed to war-torn countries. Production in 1947 amounted to nearly 11 million pounds. The peak came in 1948, when the harvest reached 21 million pounds.

But Peterson and others found that as acreage expanded, seed set, and yield declined. Native pollinating insects couldn't cope with the intensified production, and the domesticated honeybee couldn't be persuaded to forego its aversion to the tripping mechanism of the alfalfa flower to do the job. Production and yield haven't been really as high since. A crop of slightly over a million pounds in 1969 probably represents the bottom in the fortunes of Canadian alfalfa seed growers.

Peterson recalls that he only harvested two good crops in about 20 years. The absence of pollinating insects, following clean-up of natural nesting places, was blamed for the disappointing yields. Alfalfa seed production largely migrated to the United States where growers had better control of pollination and growth factors.

Soren Peterson hung on, however, and for the last five years has been using the leafcutter bee "domesticated" at the CDA Research Station, Lethbridge, Alta. Today he believes that leafcutter bees have turned the tide. They supply the key to expansion in alfalfa seed production.

"We're still learning about them," he says. But last year he managed leafcutters on 100 acres of alfalfa, and this year he plans to plant another 35 acres for seed.

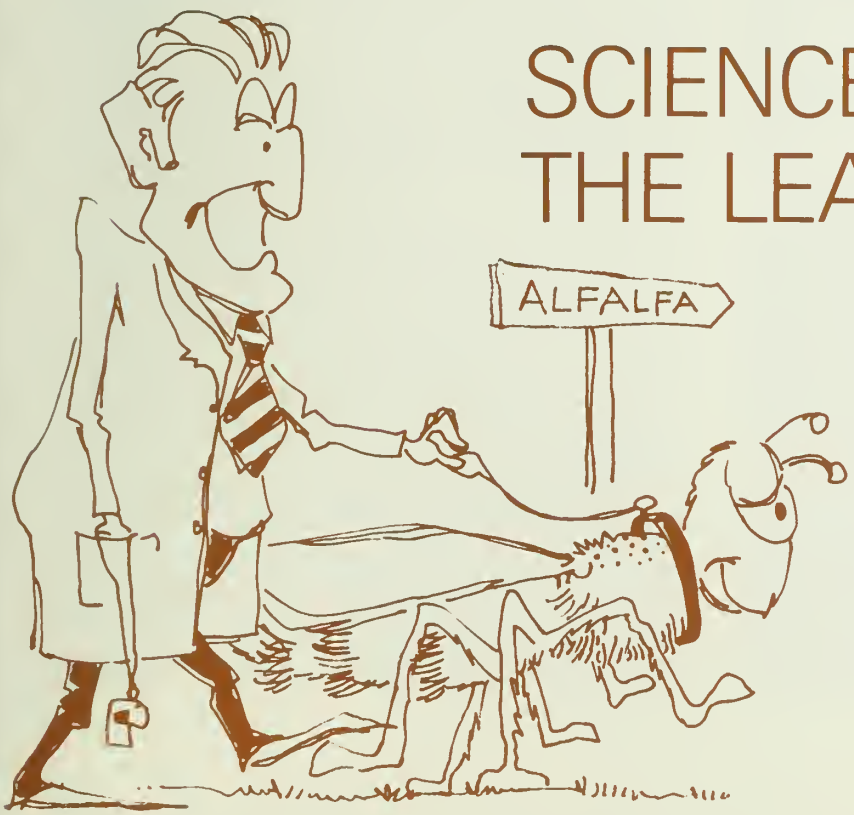
Mr. MacDonald is with the CDA Information Division, Ottawa.

WINNER AT ROYAL

Peterson was so pleased with a field of registered Beaver alfalfa last summer (it yielded 600 pounds per acre) that he entered a sample in the pedigree seed section of the Royal Winter Fair. This product of cross fertilization by leafcutter bees won the reserve grand championship and helped draw attention to the quality of seed in southern Alberta.

Regarding his prize crop of 600 pounds of Beaver alfalfa, Peterson recalls that he was lucky to get a yield of 150 pounds per acre before leafcutters.

Bob Asher of Brooks, Alta., is another agriculturist being drawn into the alfalfa seed orbit. Being a beekeeper, he appreciated the significance of the development and was the first farmer to raise leafcutters in Canada. There's money in rearing pollinating insects he believes, selling off the surplus (4 million in 1970) from year to year, or renting the pollinators on a contract basis. But he is also engaged in seed

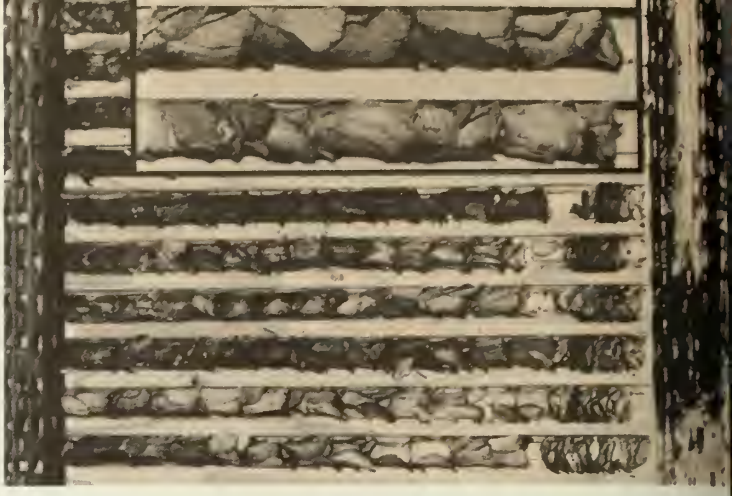


An Alberta alfalfa seed producer won the reserve grand championship at the 1970 Royal Winter Fair with his entry of registered Beaver alfalfa. For the last five years, he has been cooperating in the leafcutter bee work carried on at the CDA Research Station, Lethbridge, Alta.

production and now manages about 8 million bees, enough to pollinate 400 acres of alfalfa. He plans enough for 1,000 acres by 1973.

With domesticated pollinating insects, an average of 500 pounds of seed per acre year after year is possible, Asher believes. Good management, lower land and irrigation costs, and fewer insect problems should give growers in western Canada an advantage in world markets. There's a market for many million of pounds of alfalfa seed in the United States if growers go after it, he contends. Canada is already growing increasing supplies of seed for European countries under OECD arrangements.

But it will have to be good quality, and at a competitive price. A growing export and domestic market would depend on lower costs of production to keep prices competitive. A producer should be able to get by on a price of 50 cents a pound for alfalfa, he believes, on yields of 300 pounds per acre. The grower makes his profit on yields over 300 pounds.



Cutaway section of tunnels shows how leafcutters build nests end to end with leaf cuttings and petals.

COVER PHOTO Female alfalfa leafcutter bee with leaf cutting tucked beneath her body. (See nests built with leaf cuttings in photo above).

BUILD-UP IN SASKATCHEWAN

Alberta isn't the only province where they are making progress in alfalfa seed production as a result of the "domestication" of the alfalfa leafcutter bee. E. Norman Johnson, Director, Saskatchewan Plant Industry Branch, points out that growers in that province now have the required build-up of bees, and the experience to manage them to move ahead in production. He notes a significant increase in the establishment of seed fields in 1970. Fields of 65 acres or more in extent are being ear-marked for alfalfa seed.

The leafcutter bee was accidently introduced to North America from Europe and became adapted to certain areas of the western United States. The insect never did adapt itself to the Canadian winter so it had no impact on this country until a scientist with the Canada Department of Agriculture, Dr. G.A. Hobbs, recognized its potential and set out to domesticate it.

How do you get a wild bee to perform an essential service on thousands of acres of alfalfa in a foreign country? Hobbs faced the task with knowledge gained from his earlier studies of native leafcutters. He knew that he must aim at gaining complete control over it. There were countless unknown factors at that time. With the help of a few other scientists and producers interested in the problem, Hobbs found many of the answers that have established leafcutters as an effective pollinating agent in alfalfa. It's the key to larger seed sets, and opens the door to expanding seed enterprises.

"Now that we have learned to manage the leafcutter bee, and have the supplies," Hobbs points out, "we can grow alfalfa for seed in the Prairie Provinces almost anywhere within the triangle bounded by Lethbridge, Melfort and Winnipeg. However, even in southern Alberta, growing alfalfa for seed can be much more profitable in some areas than in others."

Dr. Hobbs outlines some of the management factors as follows:

Alfalfa can be grown for seed most successfully where the climate is warm and dry. It does best on an irrigated soil that has good water-holding capacity. By growing alfalfa on irrigated land, it is possible to control the amount of moisture it receives and thus ensure continuing bloom and flow of nutrients to the setting seed. The domesticated alfalfa leafcutter bee, *Megachile rotundata*, does not fly until the temperature is above 69°F; the warmer it is, the longer and faster the bee works. It requires dry conditions because it makes its cells with moist leaf pieces and fills them with moist pollen and honey. If the climate is too wet, mold develops in the cells and the bee larvae die. Warm dry winds cause the plants to wilt and to drop their flowers and developing seed pods. If the crop wilts after coming into bloom and after the bees have been placed in the field, management costs will increase. The crop will require at least one more irrigation and the bees in their field shelters will have to be protected from the chilling effects of the irrigation water. Irrigation at this time often creates favorable conditions for pest insects. By preventing the build-up of pest species, one can avoid the use of an insecticide that would probably require the temporary removal of the bees from the field.

Irrigated areas surrounded by rangeland are preferred for alfalfa seed production using leafcutters. The presence of rangeland usually indicates that the rainfall is too low for growing grain and, therefore, has a climate favorable for the bee. Within this irrigated area, choose fields on the side from which the prevailing winds blow. Thus with

Solving the problem of pollinating insects in alfalfa seed production required the cooperation of all groups involved, including, left to right: Dr. G. A. Hobbs, CDA Research Station, Lethbridge, Alta., representing science; Soren Peterson, Tilley, Alta., a registered seed grower; and Bob Asher, Brooks, Alta., beekeeper and contracting seed dealer.

Hives made of grooved boards to form tunnels are arranged to shelter tunnel entrances from weather conditions.

rangeland on the upwind side of the field, there is no worry about neighbors spraying with insecticides or herbicides that could harm bees or alfalfa. There is also less trouble from serious infestations of grasshoppers, which develop much more frequently in dryland crops than on rangeland.

Interest in leafcutters has spread into northern areas of the western provinces. Lower temperatures tend to restrict flying weather, however, and D.A. Cooke, forage research officer at the CDA Research Station, Melfort, Sask., is seeking answers to leafcutter bee problem in that area.

Factors that make the leafcutter the most important pollinator of alfalfa in Canada are:

- It thrives in manmade nests, which can be moved indoors in winter to protect the larvae from cold. In the spring, larvae can be incubated so they will emerge as adults when the alfalfa blooms.
- It is gregarious. Thousands of females work side by side to fill all the nests (tunnels) with cells.
- It trips and cross pollinates nearly every alfalfa flower it visits.
- It flies no farther for food than is necessary and can therefore be used to pollinate alfalfa in a particular field.
- It can be protected from predators, parasites and disease.

TUNNEL DWELLERS

Megachile rotundata live independently rather than share their livelihood in a colony like the honeybee and bumble bee. By providing a tunnel (mass produced for assembly as hives) the *rotundata* leafcutter can be induced to fill the tunnel with cells made of leaf cuttings. A female will usually build about 13 cells, end to end, in a standard 4½-inch tunnel. Males and females emerge in the proportion of about 3 to 2. Males serve no purpose but to mate with the female and once mated, the female goes about building cells from leaf pieces of flower petals.

Four fold increases can be expected annually. A 3,000 nest hive could possibly produce 20,000 cocoons by the end of the season. In any case, the increase can be stored over winter in polyethylene bags at 40°F. Fifteen days before bloom, the cells are removed from storage and spread in shallow trays for incubation at 85°F and relative humidity of 60 to 70 per cent.

In domesticating the leafcutter bee, Hobbs spent countless hours observing them at work, then trying to get them to accept more manageable living quarters and conditions. Technical problems that had to be worked out included the size and length of tunnel, materials used, condensation of moisture, brooding temperatures, disease and parasite control, field management and so on. Dr. M.D. Krunic, a post-doctorate fellow from Yugoslavia, who is working with Dr. Hobbs, is presently studying the problem of a second brood that emerges too late in the season to be effective as pollinators, or contribute to the winter carryover. These are all problems that have to be solved if growers are to make best use of pollinating insects. The extent to which leafcutter bees have been accepted is a measure of Dr. Hobbs' success in solving the numerous technical problems.

While the alfalfa seed business will recover much of its former prominence in western Canada as a result of leafcutter bees, the approach won't be quite the same. Production is much more sophisticated and requires skill as well as luck. Use of leafcutters represents an investment of at least $100 an acre. Bees sell for a cent to a cent and a half each, and it requires 10 to 20 thousand to work an acre of alfalfa. Growers must have the skill and management qualifications for such specialized production or they stand to lose a substantial investment. ■

BASIC IMPROVEMENTS IN SWEET CHERRY THROUGH

K. O. LAPINS

Ce n'est que récemment, après avoir cultivé la cerise douce pendant plus de 2,000 ans, que l'on change les caractéristiques de ce fruit. Les chercheurs de la Station de recherches de Summerland ont réussi à obtenir des spécimens nains qui sont aussi autofertiles. Toutefois, il faudra encore quelques années avant que des cultivars offrent ces caractères en plus de caractéristiques horticoles supérieures et puissent être distribués.

The sweet cherry, *Prunus avium* L. has been in cultivation for more than 2,000 years, yet until recently no basic improvement had been made in the species. The size and quality of fruit of the best cultivars are superior to those of the wild sweet cherry growing in southern and central Europe and Asia Minor, but these are small improvements and do not involve any basic changes in the main characteristics of the species. Only recently has significant progress been made, at the Summerland Research Station, in changing two important characteristics, self-compatibility (self fertility) and tree size.

Self-compatibility—The pioneer work in inducing self-compatibility in sweet cherry was begun by Lewis and Crowe at the John Innes Horticultural Institute, England, about 25 years ago. Dr. Lewis postulated that self-incompatibility could be eliminated by a mutation in the self-incompatibility (SI) gene. Both screening for spontaneous mutants and induction of mutants by irradiation of developing pollen in the three were used. In selecting natural mutants, cage-enclosed trees were self-pollinated by bees. Only those pollen grains containing a mutation in the SI gene were effective in fertilizing blossoms. This most effective method of screening millions of gametes resulted in one seedling carrying a mutation of the SI gene. Two other mutant seedlings were produced by the irradiation technique. All three John Innes seedlings are inferior in most horticultural characteristics, but each carries a (different) mutant in the SI gene.

We began breeding for self-compatibility in 1956 at the Summerland Research Station mainly using one of the original three John Innes seedlings. Crosses

Dr. Lapins specializes in fruit breeding and hardiness at the CDA Research Station, Summerland, B.C.

Compact Lambert, 4 years in orchard. The upright and dense growth allows the best use of orchard space.

BREEDING...

have been made to incorporate the self-compatibility characteristic in many breeding lines, since the primary objective of the program is to combine self-compatibility with good fruit characteristics lacking in the original John Innes seedlings. At present, about 1500 trees of these crosses are in seedling orchards awaiting evaluation, or in seedling nurseries at Summerland.

In 1968, the first cross made at Summerland in the program, Lambert × John Innes Seedling 2420, resulted in a selection which was named Stella. Stella is the first self-fertile sweet cherry to be named. Its fruit is of Lambert type, black, heart-shaped, large, ripening in mid-season. Besides being self-fertile it is also a universal pollinizer for other sweet cherry cultivars. Stella will have the greatest value in areas where weather conditions for successful cherry pollination are generally unfavorable. The cultivar has been used extensively in recent crosses, and there appears to be every reason to utilize the self-compatibility allele in all crosses in the future.

Dwarf size of tree—The sweet cherry is the tallest fruit tree grown in the temperate climate. It is increasingly difficult every year to find pickers to harvest such large trees; in fact, high harvesting expenses already threaten the future of sweet cherry growing in Europe. No satisfactory dwarfing rootstocks are now available to control three size.

We began attempts at inducing mutants of dwarf tree habit by the use of ionizing radiation at Summerland in 1956. We have used thermal neutrons, x-rays and gamma rays to irradiate dormant scions. The treated scions are grafted onto rootstocks and selections and repropagations made of individual grafts showing dwarf growth habit.

This approach has not been without its problems. As in many other plant species, we have found that reduced fertility has accompanied dwarf growth in many of the irradiation-induced mutants. However, we have discovered certain dwarf mutants with normal or even increased fertility, in comparison to the original cultivar.

In 1964, a mutant of Lambert, with compact and dwarf growth habits, was named Compact Lambert. The mutant is a true dwarf, reaching about 1/6 to 1/5 the size of a normal cherry tree on a vigorous rootstock. The fruit of Compact Lambert matures five to seven days after Lambert and resembles the fruit of the parent cultivar. A few commercial or semi-commercial test plantings of this cultivar have been made.

We have also induced mutants with compact or dwarf growth habit in cultivars other than Lambert. Since they first became available, we have intercrossed dwarf mutants of various cultivars to study the inheritance of the dwarf growth habit and to produce new cultivars of the desirable, reduced three size. Also, crosses are being made to combine the two desirable characteristics, reduced tree size and self-fertility.

It usually takes seven to 10 years from the time a cross is made until the resulting seedlings first produce fruit. Thus, it may take more than a few years until new sweet cherry cultivars will be introduced that combine self-compatibility and compact growth habit with superior horticultural characteristics. However, the genetic material is now available to breeders for the development of such improved cultivars. ■

RECLAMATION OF DYKELAND SOILS

Laboratory experiments reveal usefulness of gypsum in improving salt-affected soils

G. R. SAINI and D. A. HUGHES

Des expériences faites à la Station de recherches du ministère de l'Agriculture, à Fredericton (N.-B.), ont démontré que l'utilisation de gypse sur les sols de polder souffrant de salinité, en améliore la structure, facilite le drainage interne, élimine la salinité et accroît le rendement des cultures en laboratoire.

Dykeland or marshland soils constitute approximately 36,450 hectares (90,000 acres) at the head of the Bay of Fundy. These soils, like any other coastal alluvial soils, are normally salt-affected as a result of flooding by sea water at high tide.

In New Brunswick and Nova Scotia, some parts of flooded land were dyked by French settlers as early as the seventeenth century and used for crop production. Due to the economic depression of the 1930's and wartime scarcity of labor, the dykes and drainage ditches were not properly maintained. Consequently, dykes broke down and the soils were subjected to salt water for several years. A poor soil structure, poor drainage and high salt content resulted which rendered the land unsatisfactory for crop production (Fig. 1 and 2).

To reclaim this land from sea-water flooding, the federal and provincial governments have spent considerable sums of money for engineering construction in the recent years (Fig. 3 and 4). In certain areas not subject to flooding now, limestone has been beneficial in improving crop yields, but there are areas where salt-content is still too high. Gypsum has proved beneficial in the improvement of high-salt coastal soils in the Netherlands. Gypsum has also been used extensively in improving the soil structure of salt-affected soils in the arid zones of the world. On this basis we, at the CDA Research Station, Fredericton, N.B., have investigated the usefulness of gypsum in reclaiming the salt-affected dykeland soils on the coast of the Bay of Fundy.

Dr. Saini is a specialist in soil physics and Mr. Hughes is a technician, at the CDA Research Station, Fredericton, N. B.

Fig. 1. (Top) Poorly maintained dyke.
Fig. 2. (Center) Poor soil structure.
Fig. 3. (Bottom) Gate facilities of new dam under construction.

Drainage Improvement with Gypsum—We conducted drainage experiments in the laboratory with a tank to determine effects of amendments on rate of water percolation and on salt removal. Gypsum or limestone (10 g per Kg soil or approximately 10 tons per acre) was mixed with the soil. The treated soil was poured in the tank and water was added so as to keep a constant head of 1 inch above the soil surface. Drainage in this manner was continued for 21 days during which time the volume of drainage water (Fig. 5) and its salt content (Fig. 6) were recorded periodically. It is evident from the results shown in Fig. 5 and 6 that gypsum was a superior

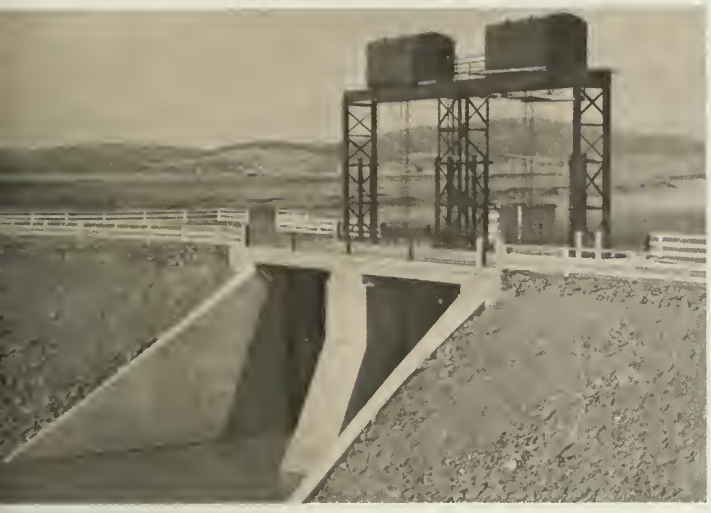


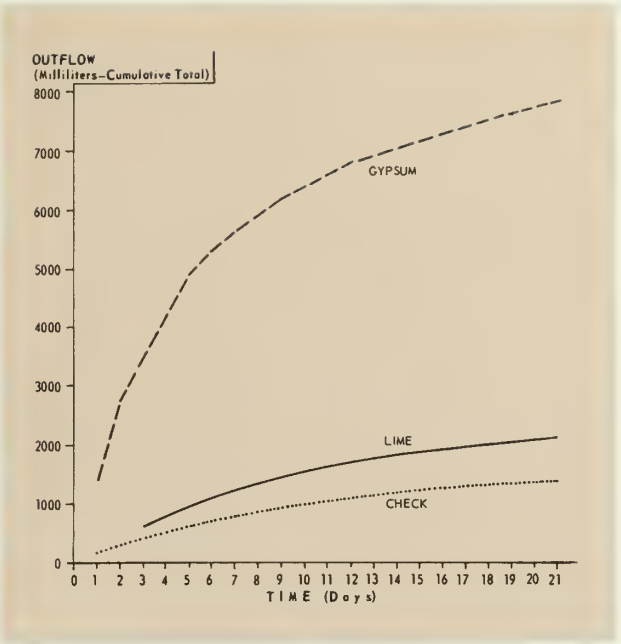
Fig. 4. New dam completed.

amendment in improving the drainage of the soil. In relative terms, the percolation rate with limestone increased 1½ times the rate of percolation without any amendment, whereas the percolation rate with gypsum was approximately 4 times the percolation rate with limestone.

Limestone and gypsum are both calcium compounds but the latter is more soluble in water. The calcium replaces sodium on the soil clay. Thus, calcium clay is formed giving the soil a porous structure, thereby enhancing the downward passage of water and removal of salts from the soil.

Crop Yield Improvement with Gypsum—Gypsum not only improved the drainage conditions and removed more salt, but it also increased crop yield in a greenhouse experiment. Limestone or gypsum were mixed with soil and leached with six inches of water. After a uniform application of NPK fertilizer the soil was planted with oats. The dry matter yields in g/pot were: No amendment 3.25; limestone 3.80; gypsum 4.66. These results show that the addition of gypsum to the soil resulted in a 44% increase in yield over no treatment, whereas the addition of limestone only showed a 17% increase in yield.

Soil Structure Important—We found that gypsum enhanced drainability by improving soil structure, facilitated salt removal and in turn increased crop yields. Now we were interested in determining if improved yields were due to improvement in structure or to salt removal. We conducted another experiment using colloidal silica instead of gypsum to improve structure. Silica was used to avoid any nutritive effects of added calcium from gypsum. Silica is practically inert and did not add any nutrients to the soil. Aggregates of a dykeland soil were prepared with colloidal silica and separated in 4 sizes from 0.5 mm to 3.0 mm. A salt solution was added to each aggregate size to bring the salinity to a level



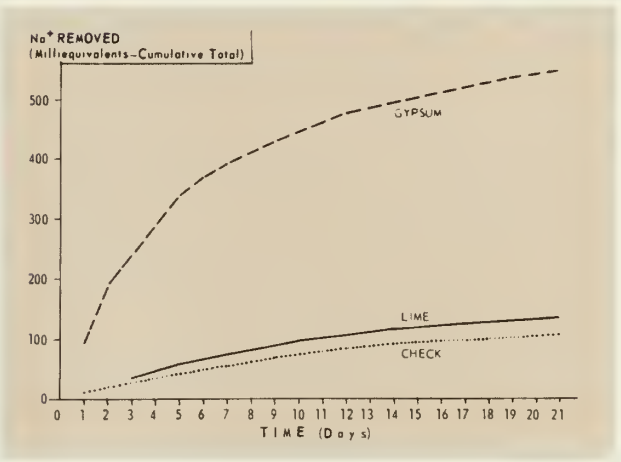


Fig. 5. (Top) Drainability of the soil with gypsum and limestone.
Fig. 6. (Bottom) Sodium removal from the soil with gypsum and limestone.

where yield of oats is retarded. The results of this experiment showed that crop yield can be improved due to better structure which provides better aeration to roots even when the soil contains injurious levels of salt.

In conclusion we suggest that a judicious application of gypsum to dykeland soils containing high salt content would be useful for growing crops. The rate of application of gypsum under field conditions remains yet to be worked out.

ACKNOWLEDGEMENT

The authors wish to thank the Department of Regional Economic Expansion (Engineering Services) for supplying Figs. 1 to 4. ■

PROTECTING CANADA'S CROPS . . .

The Post-Entry Quarantine Station of the Canada Department of Agriculture at Saanichton, B.C., aims at preventing the entry into Canada of insects and plant diseases of tree-fruits and grapes—visible or invisible.

La station de quarantaine après-entrée de Saanichton en Colombie-Britannique empêche l'entrée au Canada, d'insectes et de plantes atteintes de maladies apparentes ou non qui s'attaquent à la végétation.

Plant protection authorities the world over recognize that there is a calculated risk of plant pests and diseases being carried from one country to another on plant material for propagation. In Canada, the risk will continue as long as importations have to be made.

CDA's Plant Protection Division controls all importations of plants and plant materials required for propagation or cropping, as well as fruits and vegetables and living insects and disease specimens for scientific study.

CDA's import controls work well in keeping *visible* insects and diseased material from coming into Canada—as evidenced in the accompanying table. In 1969-70, over 288 million plant units alone passed through inspection under 8,000 import permits issued in that year, and 1,124 interceptions of pests were made.

But what about plant disease caused by viruses? They are *invisible*. Of all the organisms injurious to plants, viruses are the most difficult to detect and identify with any degree of accuracy. They are also among the most destructive, especially to fruit crops, and the only way they can be controlled is to use virus-free stock.

Since most tree fruit viruses are spread by the grafting of diseased scions or budding material onto healthy stock rather than by insects, soil, or other means, precautions have to be taken to ensure that fruit trees or grafting material entering Canada are free of viruses.

It was to accomplish this objective that the C.D.A. Post-Entry Quarantine Station was established at Saanichton on Vancouver Island. All imported tree-fruit materials and grapes for research purposes are routed directly to this station. These materials are propagated at the station, and subjected to specified tests over a period of from one to three years before being released to the importers. This procedure allows quarantine officers to observe imported material over a period of time, and to identify diseases and pests which would not be readily detected by examination of the material at the port of importation. The procedure also allows the staff of the station to carry out involved and lengthy indexing procedures for the detection of virus diseases, and thus to identify virus-free material for further propagation and release to the importer.

When the Post-Entry Quarantine Station was established at the Saanichton Research Station in May 1965, it was mainly concerned with indexing grape, fruit-tree and related ornamental stocks imported from Europe and Asia for scientific purposes by the CDA Research Branch. Up to that time, the north-

Prepared by CDA Information Division for Plant Protection Division, CDA Production and Marketing Branch, Ottawa.

The secondary quarantine stage. Here, technician is grafting grape vine virus indicators into dormant imported grape plants.

western countries of Europe had been Canada's traditional source of commercial tree-fruit material and new virus diseases had posed no serious problem in importations. However, these countries had started trading within the European Common Market, and serious virus diseases known to exist in southern and southeastern Europe were beginning to appear in western Europe.

Many of these viruses could have created havoc in the Canadian fruit industry, as the little cherry disease did in British Columbia's Kootenay Valley; introduced with Japanese flowering cherry trees, this disease by 1950 had destroyed the cherry industry in that area. Other examples: Pear moira has ruined pear growing in parts of Italy; apple proliferation virus, from the Balkans, could destroy our Golden Delicious apples; and plum pox from the same area certainly would attack our best varieties of plum, peach and apricot.

"It soon became evident that our quarantine virus indexing facilities would have to be expanded to handle shipments of commercial tree-fruit and grape stock from overseas, as well as the scientific importations," says Dr. W. P. Campbell, Chief, Technical Services, CDA Plant Protection Division.

"Furthermore," he says; "many importing countries began to insist on special declarations indicating that fruit stock being shipped to their countries was free of specific plant viruses."

More land was made available to the Post-entry Quarantine Station at Saanichton in 1967.

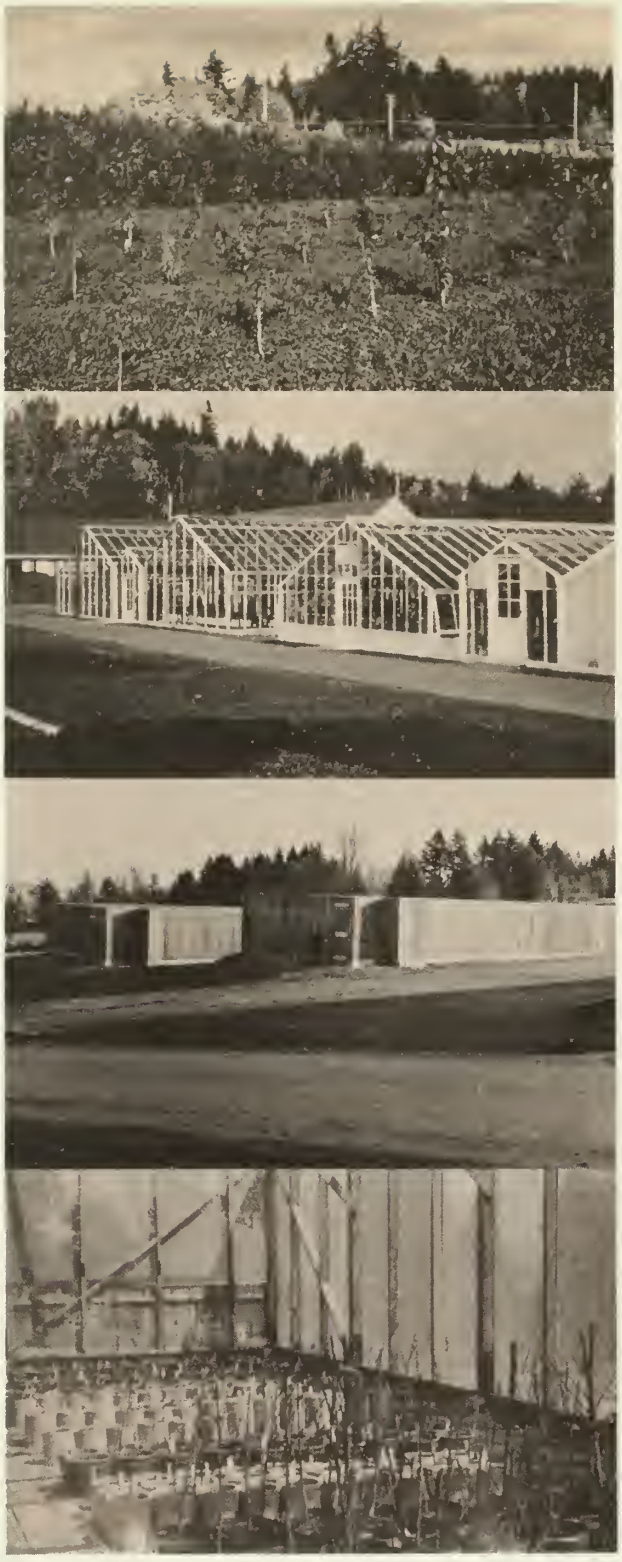
The Station is ideally situated on Vancouver Island, where the climate is suitable for growing whatever species or varieties might be required in Canada. It is isolated from commercial tree-fruit and grape plantings, thus reducing the risk of introducing new diseases and pests into a major fruit crop region.

The program is coordinated by a plant pathologist from the Ottawa headquarters of the Plant Protection Division. From time to time, fruit-virus specialists of the CDA Research Branch are called upon for assistance.

DETECTING INVISIBLE VIRUSES

The Post-Entry Quarantine Virus Indexing Station serves as a repository for imported materials that indexing has shown to be free from dangerous virus infection. It receives, propagates and indexes tree-fruit and grape materials being imported into Canada for experimental use from countries other than the United States.

There are three phases in plant quarantine for virus indexing—primary, secondary and tertiary quarantine. On arrival at the Station, candidate (or test) plants for certification are given quarantine numbers to identify them. During primary quarantine, the plants are chemically treated and perpetuated on disease-free rootstocks. Treated trees are maintained



Top—A block of Mazzard cherries being indexed.

Second from top—Modern facilities at the quarantine station include greenhouses.

Third from top—Screenhouse facilities at Saanichton where mother plants are held pending indexing results; used to prevent insects spreading viruses from diseased plants (See article on spreading virus diseases on page 14).

Bottom—Virus-free root stocks grown in containers and indicators in quarantine screenhouse.

in quarantine screenhouses where they are observed periodically. Annual or herbaceous-host indexing is performed. The candidate clones are destroyed if any infection of a serious nature develops during this period of isolation. This primary phase of herbaceous-indexing is a relatively new concept in screening for virus diseases. Because annual plants are used as hosts for the virus, screening can be completed in six to eight weeks instead of several years using woody-indexing. For example, detecting a virus on an apple tree would take as long as the tree takes to bear fruit—two to three years using woody-indexing.

However, plants that pass the primary phase of quarantine undergo further isolation. During secondary quarantine, graft inoculation on related species and specific virus indicators is done. The indicator range is predetermined depending on where the imported material originates. The indicator range includes varieties that index for virus diseases possibly occurring in such areas as Europe, the Orient or Australasia, or among the common domestically prevalent viruses. Plants infected with virus diseases are subjected to heat therapy during this phase to inactivate the disease organism.

Once they have passed the first two phases of quarantine (primary and secondary), plants are allowed to grow under normal field conditions. This open period is a further test. If symptoms develop during this tertiary quarantine, the clone may be recalled and disqualified from certification. The average length of quarantine from reception to tertiary stage is from two to three years depending on the virus that may be present.

To date, over 600 new varieties have been tested for domestic and foreign pathogens. Because full indexing takes so long, however, it was not until 1968-69 that more than an occasional virus could be reported. Now, for the first time, a list of virus diseases found in fruit stock intended for importation to Canada has been compiled. The Post-Entry Quarantine Station made 82 interceptions of imported virus-infected grape and tree-fruit material during the year. Viruses that attack apple trees were the most common but grape, cherry and plum disease viruses were also found. ■

INSPECTION AND IMPORT ACTIVITIES, 1969-70

In 1969-70, the Division granted 8,560 import permits and inspected the following shipments before releasing them to importers:

Plant units	288,005,000
Tree and shrub seeds (pounds)	13,230
Regulated plant products (tons)	124,830
Insects and biological cultures	476

The shipments originated in 33 countries. Inspectors made more than 1124 interceptions, of which 424 were serious enough to prohibit importation of the shipment.

POWDERY MILDEW OF WHEAT in the maritimes

H. WINSTON JOHNSTON and
J. D. E. STERLING

Le blanc du blé semble être la principale maladie s'opposant à la production du blé dans les Maritimes. La meilleure lutte contre cette maladie est de produire par le croisement sélectif des variétés résistantes. C'est ce qui se fait à la Station de recherches du ministère fédéral de l'Agriculture à Charlottetown.

Feed wheat production in the Maritimes has increased in recent years because of the development of higher yielding and better adapted varieties. This has offered Maritime growers the opportunity of increasing returns per acre and reducing their dependence on imported feeds. The position of wheat production has been improved with the availability in 1969 of the spring wheat Opal, and Yorkstar winter wheat. These varieties have better combinations of high yield and general adaptability.

Diseases are one of the limiting factors in wheat production in the Maritime area, but the wheat rusts which can be very destructive in other parts of Canada normally do not cause severe damage. Although high moisture levels have the potential of benefiting yields of Maritime grain crops, these levels also promote some diseases. Many of the diseases are found only occasionally and are of minor consequence, with one exception—powdery mildew. It is widespread and is considered the principal disease limiting wheat production in the Maritimes. Powdery mildew of wheat is caused by the fungus *Erysiphe graminis* DC. ex Merat f. sp. *tritici* Marchal.

Both fall and spring seeded wheats are infected by powdery mildew. Wheat seeded in the fall has much earlier spring growth and show signs of mildew infection in early May. Spring seeded wheats, usually planted in May and by June, are frequently infected as early as the 3rd or 4th leaf stage. Disease intensity on both types of wheat increases as the plant matures. This occurs in early August for the fall seeded wheat and late August to September for the spring seeded wheats. The fall wheats are considered to be the principle inoculum source of the mildew which infects the spring wheat.

Research at the Charlottetown Research Station for the control of mildew on wheat has taken two lines of approach. First, by testing seed treatments and, secondly, by producing resistant varieties through plant breeding.

Seed dressings with systemic fungicides do not appear satisfactory for the control of powdery mildew on fall seeded wheat. Slight delay in the appearance of symptoms in the spring has been noted but yields have not been improved. Such seed dressings do not persist from fall seeding to the following spring. However, seed applied fungicides do appear to effectively control the disease in the spring wheats (Table).

The most promising seed dressings to date appear to be millstem and benlate. In treated plots, the mildew lesions do not appear on the upper leaves until the beginning of ripening and less yield decrease occurs. Millstem is slightly more persistent than benlate and is capable of almost complete mildew inhibition in the initial stages of infection. These compounds are both experimental, but at least one may be available commercially by 1972.

More economical and effective control at present appears to be through the development of resistant varieties. Although differing somewhat in their reaction to *E. graminis*, all commercial varieties grown in the Maritimes are moderately to highly susceptible to local physiological forms of the organism. However, several European varieties of the spring type have demonstrated good resistance to the disease in recent trials, notably Janus, Rothwell Sprite, Maris Ensign, and Kleiber. The variety Kolibri appears to have complete immunity to local forms and this variety is being used extensively in crossing to both spring and winter types. The F_1 and early generation segregates suggest that the immunity of Kolibri is dominant in the crosses under study. ■

INFLUENCE OF MILLSTEM AND BENLATE ON THE SEVERITY OF POWDERY MILDEW ON OPAL AND SELKIRK WHEAT.

	Opal			Selkirk		
Growth Stage	Millstem	Benlate	Check	Millstem	Benlate	Check
1st Node	0.00	0.00	0.15	0.05	0.00	0.25
"Boot"	0.00	0.00	0.27	0.11	0.56	11.26
Flowering	0.35	0.40	1.07	2.60	3.25	46.50
Milky Ripe	11.70	12.00	18.25	12.55	15.50	57.80

The authors are cereal pathologist and plant breeder, respectively, at the CDA Research Station, Charlottetown, P.E.I.

HOW INSECTS SPREAD PLANT VIRUS DISEASES

A. R. FORBES, J. RAINE, and
H. R. MacCARTHY

Les pucerons et les cicadelles sont les principaux insectes vecteurs de maladies à virus. La connaissance du mode d'acquisition et de transmission des virus permet de trouver des méthodes de lutte efficaces.

Insects are the most important carriers or vectors of plant diseases. By feeding on a diseased plant they acquire a virus or other disease-producing agent, which they transmit to healthy plants that they feed upon later. More than 200 plant viruses are known to be transmitted by insects and almost all agricultural crops are susceptible to one or more of them. Some of the diseases caused by these viruses do little harm but others inflict serious losses and are widespread. At the CDA Research Station, Vancouver, we are studying how insects acquire and transmit plant viruses, to enable us to devise ways to stop or slow the spread of the diseases.

Nearly all of the insects that transmit plant viruses feed by sucking sap from plants. This method of feeding and the insect mouthparts are ideal for spreading viruses or other pathogens from plant to plant. The mouthparts consist of two pairs of needle-like stylets. The inner pair, the maxillary stylets, are interlocked to form a large food canal and a smaller salivary canal. The functional mouth is at the tip of these maxillary stylets. When piercing a plant, the mandibular stylets work alternately making a channel for the maxillary stylets. When feeding, the aphid sucks plant sap up the food canal and pumps saliva down the salivary canal.

Of the vector insects, aphids are the most important with more than 180 vector species, followed by leafhoppers with about 100 vector species. A few species of spittle bugs, scale insects, whiteflies, mealybugs, thrips, and mites are also carriers of plant virus diseases. Some chewing insects such as beetles, grasshoppers, and earwigs can transmit a few viruses mechanically on their mandibles or by regurgitation.

The most important vector aphid in Canada and throughout the world is the green peach aphid, *Myzus persicae* (Sulzer). This aphid feeds on many crops and ornamentals and is capable of spreading more than 100 viruses. One of the economically serious virus diseases transmitted by this aphid is potato leaf roll. We have given special attention to this disease at Vancouver. Aphids that have spent their life on a diseased potato must feed on a healthy potato for at least 30 minutes to infect it. A non-infective aphid must feed on an infected for 2 or more hours to acquire the virus but cannot then infect another plant for several hours afterward. Both winged and wingless aphids can transmit the virus and both show the same virus-vector relationships. In the field, winged forms are the most important since they can fly considerable distances and spread the virus widely; the wingless forms sometimes move from plant to plant along and between rows spreading some disease.

The following mechanism has been advanced to explain these virus-vector relationships. The aphids must find the phloem and acquire the virus together with the plant sap through the food canal in the stylets. In the gut, the virus particles must pass

The authors are with the Entomology Section, CDA Research Station, Vancouver, B.C. Dr. Macarthy is Section Chief, Dr. Forbes specializes in Ecology, and Mr. Raine, soil insects and biological control.

Fig. 1. Greatly enlarged photograph of winged and wingless green peach aphids.

through the gut wall, then reach and enter the salivary glands before they can be injected with the saliva into the phloem of another plant when the aphid feeds again. The whole process takes several hours. Moreover, there is evidence that the virus multiplies in the aphid, before entering the salivary glands. With these virus-vector relationships, potato leaf roll virus is classed as circulative and persistent: circulative since it moves through the insect's body and persistent since it renders the insect infective for life.

Since most virus is spread by winged forms, we used traps to determine the numbers of green peach aphids flying throughout each growing season during several years. The trapped aphids were collected weekly and the green peach aphids were counted. Trap catches and field surveys showed that steckling sugar beets and a few weeds are important overwintering hosts for the green peach aphid in the Fraser Valley. Overwintered aphids start reproducing early in the spring and then colonies are produced on summer hosts including potatoes. Many winged forms are produced later, and the peak of their flight is during the first half of August.

Based on these virus-vector relationships and flight data, control measures recommended in British Columbia are to plant only potato seed certified free from leafroll virus, to rogue diseased plants early and often, to top kill early in August, and to control aphids. Only such a combined program works; chemical control of aphids is not enough.

On the other hand, the green peach aphid can transmit potato virus Y in less than a minute. The aphid acquires the virus as soon as its mouthparts puncture the epidermis of the leaf and it can transmit the virus immediately after it leaves the infected plant and probes a healthy one. Only a few plants can be inoculated from a single charge since infectivity is rapidly lost. A possible explanation for these facts is that on probing the epidermis, the aphid's mouthparts become contaminated with virus particles which are inoculated into the epidermis of other plants which the aphid probes within a short time after leaving the diseased plant. The mandibles of an aphid have barb-like ridges near their tips and the virus particles may be carried behind these ridges.

On the basis of these virus-vector relationships, potato virus Y is classed as stylet-borne and non-persistent. There are a large number of aphid-transmitted viruses in this group including those causing mosaic diseases of bean, lettuce, celery, dahlia, cucumber, and cauliflower.

The idea of simple mechanical transmission on the mouthparts does not explain variations in efficiency of transmission nor specificity, i.e., why one aphid species can transmit a given stylet-borne virus more efficiently than another, or why one species can transmit a virus whereas a closely related species cannot. Some complicated theories have been advanced to explain these phenomena but we still do not have the full story.

Leafhoppers are small but they fly readily and sometimes long distances. Most of the leafhopper-borne viruses, whose virus-vector relationships are known, are propagative and are transmitted in a manner similar to that described for the circulative aphid-borne viruses. Several leafhopper-borne viruses can be passed from an infective mother to her offspring through the egg.

Yellows diseases such as aster yellows, which are transmitted by leafhoppers, were previously thought to be caused by viruses. Recent studies in Japan, France, and the United States strongly implicate another group of microorganisms, the mycoplasmas, as their causal agents. Mycoplasmas are distinct from both bacteria and viruses and may be considered as belonging between these two groups of pathogenic agents. Aster yellows is a serious disease of many cereal, forage, horticultural, and ornamental crops in Canada accounting for losses in millions of dollars in some years. It is transmitted by the six-spotted leafhopper, *Macrosteles fascifrons (Stal), following a long incubation period in the insect.* ■

Fig. 2. Greatly enlarged photograph of a leafhopper.

Fig. 3. A scanning electron micrograph of the tips of the mandibular stylets of the green peach aphid, showing the external barb-like ridges.

ECHOES
FROM THE FIELD AND LAB

Shown above is a winter view of the new Canada Department of Agriculture Research Station at Ste-Foy, Que., which recently began operations.

Ci-dessus: Vue hivernale de la station de recherches du Ministère fédéral de l'Agriculture à Ste-Foy, Qué., qui a récemment ouvert ses portes.

BRITISH COLUMBIA BRUCELLOSIS FREE The province of British Columbia has become a brucellosis free region of Canada. This was recently announced by federal Agricultural Minister H. A. (Bud) Olson and provincial Agricultural Minister Cyril M. Shelford.

The status was reached when the North Okanagan area was declared free of this costly cattle disease by the federal Health of Animals Branch and joined the other 19 areas of the province in this distinction.

The province showed early initiative in the control of the disease. It had established its own calf vaccination program in 1942 (which was merged with the federal vaccination program in 1952) and a brucellosis test area plan in 1949. The plan was voluntary and areas for testing were set up at the request of local livestock owners.

The designation of British Columbia as brucellosis free is a big step forward in the federal program launched in 1957 to eradicate the disease in Canada. The federal program of blood-testing of cattle and slaughter of reactor animals was introduced at a time when brucellosis was costing Canadian cattle owners an estimated $9,000,000 a year from decreased milk yields, loss of calves and the cost of replacement animals.

It was also jeopardizing the export market for Canadian cattle.

To qualify as a brucellosis free area, no more than one per cent of the cattle herds and no more than a fifth of one per cent of the total cattle population can be found infected during an 18-month period. Also, the infection must have been eradicated from those herds in which it was found to exist. Although an area or region may be designated brucellosis free, testing is continued in order to detect infected animals that could trigger a new outbreak of the disease.

About 400,000 head of cattle in 15,760 herds were tested in British Columbia under the program. Compensation was paid to owners by the federal government for more than 1,700 reactor animals that were slaughtered.

WEATHER MODIFICATION REPORT The Canada Committee on Agricultural Meteorology has recently released a report in which it says that there is evidence that much has been accomplished to date toward ways and means of increasing rainfall and reducing hail storms in Canada. Also, certain aspects of weather control are feasible.

Entitled "Weather Modification", the report cautions that much more experimentation and research is needed to bring a measure of understanding and control into the subject, and that much more research is required before any attempts can be made to put large-scale weather control on any operational basis.

It is also most important to determine well in advance what the net benefits would be from weather control. Both beneficial and harmful results can be expected in both the ecological and socio-economical areas. This can be determined only by adequate research programs.

Some of the benefits of weather control are obvious, particularly for agriculture.

One is that an increase in prairie rainfall during the dry summer months could increase grain production. It has been shown that a 10 per cent increase in rain in June and July over selected areas would mean a two to three per cent rise in Canadian wheat production. That would be worth from $20 to $30 million. A 30 per cent increase would be worth more than $50 million.

Controlled rainfall would be beneficial to forest and hydro-electric developments. The tourist industry, all recreation and sports activities, municipal planning and the military are a few other areas which would reap large benefits from controlled weather modification.

The report was prepared under the auspices of the Canadian Agricultural Services Coordinating Committee as part of a general review of progress towards increasing rainfall and reducing hail in Canada.

BEANS COULD BE OFF-BEAT WESTERN CROP Farmers in the Prairie Provinces could try beans as an off-beat crop. Beans have been grown for many years in other areas of Canada, notably southwestern Ontario, but are new to the Prairies.

Last year commercial interests experimented with 2,000 acres of three different types and obtained an average yield of 700 pounds per acre. And at the Canada Department of Agriculture Research Station, Morden, Man., yields of up to 1,000 pounds an acre were produced on test plots.

The three species tried by the commercial interests were the commercial dry, white or navy bean, the adzuki bean and the mung bean. Farmers receive a market price of from five to seven cents per pound of seed.

Each year about 600 tons of navy beans are used on the Prairies alone. They are marketed through grocery stores for home consumption and through contracts with processors for soup and pork and beans.

Adzuki beans have been grown at the Morden station since 1944. In 1970 they were acclaimed by commercial interests as an important potential export. Mung beans are used for producing bean sprouts.

Bean plants do not grow well in competition with weeds and chemical weed control may be necessary. The plants should be spaced in rows 24 to 30 inches apart. Shallow cultivation is good.—C. WALKOF, MORDEN, MAN.

LIVESTOCK FEEDING GUIDE An important new publication for livestock producers in the Atlantic region of Canada has resulted from collaboration between scientists of the Canada Department of Agriculture and provincial experts.

Called "Feeding Guide for the Atlantic Provinces", the booklet contains such information as ration formulation and nutrient requirements of various classes of livestock to help farmers with their livestock feeding problems.

In their foreword to the bulletin, the authors point out that, although more than half of the total income in the Atlantic region is derived from livestock and livestock products, livestock owners in the area, to remain competitive, must continue to increase the efficiency of their production. This can be done, say the authors, by following an improved feeding program which ensures not only that the livestock receive good feed, but that feeding earns a profit.

Text and tables in the 32-page publication

ECHOS
DES LABOS ET D'AILLEURS

cover such subjects as classes of nutrients in which energy, protein, vitamins and minerals are discussed, and classification of livestock feeds in which the differences between roughages, basal feeds and protein supplements are described.

A copy of the publication may be obtained without charge from the Information Division of any provincial agriculture department in the Atlantic region, or from one of their agricultural representatives.

FARM LOANS Answers to a multitude of questions concerning loans made to farmers by the Farm Credit Corporation are contained in a new publication of the Corporation.

Titled "Federal Farm Credit and Related Statistics", the bilingual publication features commentary and tables to present a wealth of statistical data on farm lending and farm businesses accumulated during the Corporation's first decade of operations. The FCC was established in 1959 as successor to the Canadian Farm Loan Board.

The booklet answers such questions as: What types of credit are provided through federal legislation? How many farmers borrowed last year and how much? In 1960? What trends have developed in farm size and numbers and in the purposes for which loans were taken out?

The purpose of the publication, which contains not only statistics of FCC operations but also related data from other sources, is to fill a need for more comprehensive statistics on farm finance.

The statistical contents cover a wide area and include lending, land values, effect of loans on income and assets, sizes of farms, productivity and prices.

For a free copy of the publication, write: Farm Credit Corporation, P.O. Box 4209, Postal Station E, Ottawa 1, Ont.—GEORGE OWEN, CHAIRMAN, FARM CREDIT CORPORATION

LES PRÊTS AGRICOLES Une nouvelle publication appelée *Les statistiques relatives au crédit agricole fédéral* répond à une multitude de questions faites par les agriculteurs à la Société du crédit agricole. Cette publication bilingue, par des commentaires et des tableaux, offre une mine de renseignements statistiques sur les prêts aux fermes et sur les entreprises agricoles accumulés au cours de la première décennie de cette société qui a succédé à la Canadian Farm Loan Board depuis 1959.

Cette publication répond à des questions telles que: Quel genre de crédit peut être obtenu suivant la législation fédérale? Combien de fermiers ont emprunté l'année dernière et quelle somme? Combien l'ont fait en 1960? Quelles sont les tendances qui se sont manifestées par la grandeur des fermes et leur nombre? Dans quel but les prêts ont-ils été contractés?

Afin de satisfaire à une demande de statistiques globales sur les finances des fermes, cette publication contient les statistiques de la Société de crédit agricole mais aussi des renseignements d'autres sources.

Elles décrivent aussi bien les prêts, la valeur des terrains, les effets des prêts sur le revenu et les possessions, la grandeur des fermes, la rentabilité et les prix.

Pour obtenir une copie gratuite de cette publication écrire à: La Société de crédit agricole, Boîte postale 4209, Succursale E, Ottawa 1, Ontario.—GEORGE OWEN, PRÉSIDENT, SOCIÉTÉ DE CRÉDIT AGRICOLE.

NEW OAT VARIETY Random, a new oat variety, has been developed and licensed by the Canada Department of Agriculture. It combines high yield with excellent lodging resistance and early maturity.

Developed by plant breeders at the CDA Research Station, Lacombe, Alta., it yielded 10 per cent more than the Rodney variety during tests across western Canada. It was also slightly earlier maturing than Rodney.

Its straw is five to 10 inches shorter than most varieties grown today. This gives it a lodging resistance equal to the Pendek variety, which has much better lodging resistance than most varieties.

Random was developed from a cross between Glen and Pendek.

Seed growers in the three Prairie Provinces will multiply Random seed stocks this year, and enough registered seed should be available for general planting by the spring of 1972.

The Seed Section of the CDA Research Station, Regina, Sask., will contact selected growers to determine their interest in taking part in this year's seed multiplication program.

YIELDS FROM BRUSSELS SPROUTS If growers of Brussels sprouts check the nitrate nitrogen content of their soil at transplanting time, they may be able to anticipate their yields. After experiments at the Canada Department of Agriculture Research Station, Charlottetown, P.E.I., it was found that the quantity of nitrate nitrogen in the soil at transplanting time is the best indicator of that soil's potential for Brussels sprout production.

However, this test will predict only the potential of a soil as a low or high yielder of Brussels sprouts. It will not tell farmers how much nitrogen fertilizer is needed in a particular soil to get these maximum results.

The same quantities of nitrogen fertilizer have been applied to both potentially low and high yielding soils and, in both cases, a maximum sprout yield has resulted. A low yielding soil could not be converted to a high yielding soil by additional nitrogen fertilizer, even when adequate phosphorus, potassium and micronutrients were applied.

In general, maximum yields of Brussels sprouts can be expected when between 55 and 90 pounds of nitrogen per acre is applied in the fertilizer. This was proven by experiments carried out in 12 locations on Prince Edward Island over a three year period. A level of 5.2 per cent nitrogen is needed in leaf tissues for good yields and a 5.6 per cent level for maximum yields.—D. C. MUNRO, CHARLOTTETOWN, P.E.I.

SHEEP BREEDING An experiment under way for the past six years at the Canada Department of Agriculture Research Station, Lethbridge, Alta., should help sheep breeders in choosing breeding stock.

The relative merits of the Romnelet, Columbia, N.C. Cheviot and Suffolk breeds have been compared, as well as the performance of crossbred offspring.

Little difference was found among the Romnelet, Columbia and N.C. Cheviot breeds in terms of weaning weight, final market weight, total feedlot gain and weight-per-day of age.

The Suffolk breed was considerably better in all of these traits. Weaning weight was nine to 12 pounds better, final market weight was 13 to 20 pounds better and weight-per-day of age was .07 to .11 of a pound better.

The most striking and significant effect was found in the maternal ability of the Suffolk. Dams of this breed raised lambs 10 pounds heavier at weaning time than the dams of the three other breeds.

Single crosses were, on the average, four to five per cent better in the four traits, and three-breed crosses were seven to 18 per cent better than the pure breeds.—J. A. VESELY, LETHBRIDGE, ALTA.

CORRECTION (Page 9, *Canada Agriculture*, Winter 71): Middle column figures in top table should be doubled, and second sentence, last paragraph, should read . . . "in Island soils is only 82 and 57 percent . . .". Also, top table should read Table 2 and the lower one, Table 1.

CORRECTION (Page 2, *Canada Agriculture*, Winter 71): Should read Volume 16 Winter 1971, No. 1 — not No. 4 as printed.

ERRATA (Page 2, *Canada Agriculture*, Hiver 71): Lire Volume 16, Hiver 1971, N° 1 et non N° 4.

W. CLIVE JAMES

ESTIMATION

Les pertes de récoltes par maladie préoccupent les producteurs du monde entier. Les scientifiques canadiens ont étudié un programme pour établir des méthodes précises d'évaluation de ces pertes.

The estimation of crop losses due to disease has gained international attention and concern. At the Food and Agricultural Organization's Symposium on Crop Losses held in Rome in 1967 the inadequacy of present methods for assessing disease incidence and crop losses was well recognized. So much so that the FAO recommended that national governments use more precise methods.

Canada was represented at the Symposium and to date it is believed to be one of the few countries that has acted positively on the recommendation by developing a program for this purpose. The team consists of four plant pathologists based at Ottawa Research Station who specifically work on crop losses and co-ordinate crop disease loss programs from 13 regional plant pathologists in other provinces, who are part of the overall crop disease loss program.

WHY DO WE NEED CROP LOSS ESTIMATES?

The first plant pathologists justified their discipline because diseases caused losses in yield or quality; yet today there is little information on the quantitative relationship between disease incidences and the consequent losses. Most of the current information on crop losses is the result of subjective impressions—and first impressions are often wrong!

In order to develop rational and economical plant protection measures, whether this be by breeding resistant varieties or using fungicides, it is a prerequisite that we have a reliable estimate of the loss. If a reliable dollar value cannot be estimated for the loss, how can we decide how much to spend on disease control? It is not enough to know that disease causes a loss; we must know the magnitude of the loss so that this can be related to plant protection costs and thus enable the farmer to operate a control program which is profitable.

Priorities in plant pathology must be established as in any other discipline and the Research Branch of the Canada Department of Agriculture is recognizing this by implementing its "Management by Objectives" policy. Reliable estimates of the losses associated with different diseases are needed to determine the relative importance of plant diseases so that research priorities in plant pathology can be established.

Dr. James is a plant pathologist in the Crop Loss Section, CDA Ottawa Research Station, Ottawa, Ont.

HOW TO OBTAIN RELIABLE ESTIMATES

There are no specific methods that can be applied to all plant diseases but a general strategy can be defined. The program is usually divided into two stages: experimental and survey.

The experimental stage is necessary to determine the quantitative relationship between disease incidence and loss in yield. It involves a study of the development of the disease throughout the season as well as monitoring the growth of healthy and diseased plant populations. From this knowledge, keys are prepared to identify the different plant growth stages and disease assessment methods are also developed to measure disease. The disease assessment keys usually describe the appearance of the crop when attacked by different levels of disease. An example is the potato blight key shown below.

KEY FOR THE ASSESSMENT OF POTATO LATE BLIGHT ON FOLIAGE

Blight (percent)	Nature of infection
0.0	No disease or none observed.
0.1	;A few scattered plants blighted; up to 1 or 2.
1	Up to 10 spots per plant; or general light infection.
5	About 50 spots per plant; up to 1 in 10 leaflets infected.
25	Nearly every leaflet infected, but plants retaining normal form; plants may smell of blight; field looks green although every plant is affected.
50	Every plant affected and about 50 percent of the leaf area is destroyed; field appears green, flecked with brown.
75	About 75 percent of leaf area destroyed; field appears neither predominantly brown or green.
95	Only a few green leaves on plants, but stems are green.
100	All leaves dead, stems dead or dying.

In other cases diagrams are used to typify the development of the disease and the severity of attack is usually defined as the percentage area affected by disease. Examples of this type of key are shown in Fig. 3. Irrespective of which disease assessment method is used, the keys must be designed so that

OF CROP LOSSES

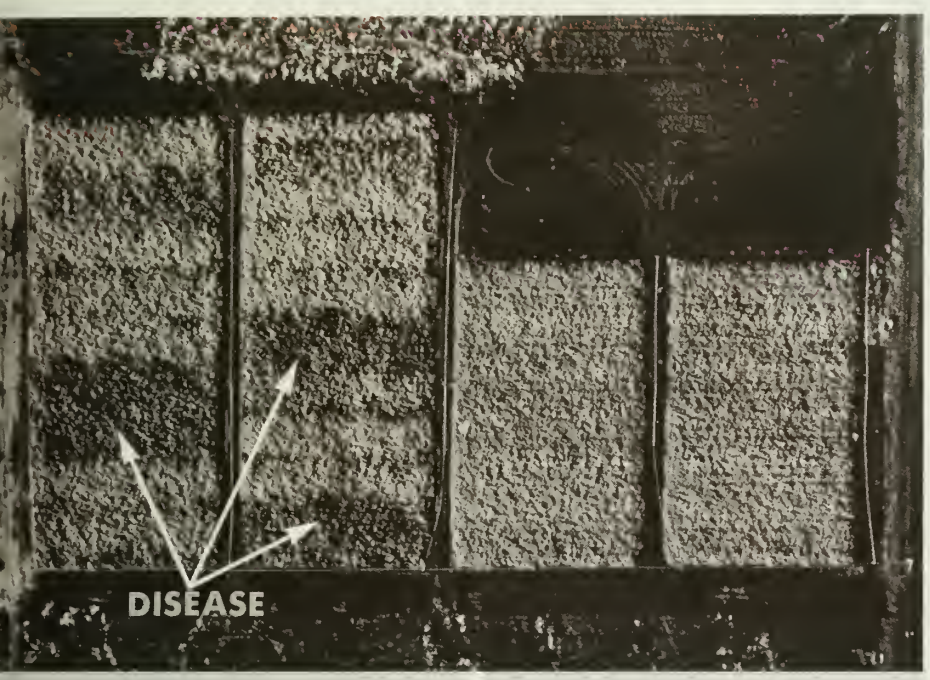


Fig. 1. Color infra red aerial photography (reproduced in black and white) of a potato experiment conducted by the author on the Central Experimental Farm, Ottawa, 1970. The darker areas represent the plots affected by the late potato blight disease (Phytophthora infestants). *Contact scale is 1/520.*

Fig. 2. Author assessing diseases on barley.

Fig. 3. Disease assessment keys used to estimate (a) the damage caused by glume bloth (Septoria nodorum), *a disease which affects spikes of wheat (b) the damage caused by mildew* (Erysiphe graminis), *a disease which affects leaves of wheat.*

Fig. 4. Assessing the damage to barley leaves caused by mildew.

different observers record similar values for any particular crop or plot affected by disease.

A series of field trials is then conducted using standardized methods of identifying the host growth stage and assessing disease. The trials are repeated for two to three years at different locations using current varieties. In each trial the disease is allowed to develop in some plots but it is controlled in others. Disease progress curves are obtained for the plots and the associated yields are determined. The final step in the experimental stage is to establish whether a quantitative relationship can be defined between disease incidence and yield loss. Furthermore this relationship must be shown to be consistent for all circumstances, or exceptions must be noted and the necessary corrections applied. If all these requirements are satisfied it can be said that a prediction method has been developed to assess yield loss, given the necessary disease data.

The second stage involves assessing the disease incidence on plants from a representative number of farmers' fields, using the assessment method developed in the first stage. Knowing the quantitative relationship between disease incidence and yield, the loss can then be calculated. Statistical procedures must be used to select a meaningful sample of fields and subsamples of plants within the fields. Surveys are usually repeated two or three times to detect the variability in disease incidence from year to year.

THE CANADIAN PROGRAM

Although the program was only started two years ago, projects at many research stations have been reorientated to cater for the program's need. The nature of disease assessment problems dictate that a final result will not be forthcoming for two to three years. In this article it is not possible to comment on all the projects, but a few will be selected as examples.

Experiments at Fredericton, Charlottetown and Ottawa over the past two years have attempted to relate the level of late blight on the foliage of potatoes to the consequent decrease in tuber yield. Losses in tuber yield of 50 percent and over have been recorded for this disease. This is probably the most important potato disease in eastern Canada, and although crops are sprayed regularly with fungicides, the disease is still prevalent. Preliminary results suggest that the decrease in tuber yield, associated with a particular level of disease, is much greater in eastern Canada than in Europe. When a reliable method is established for Canada, a realistic estimate of the losses due to late blight can be calculated. A similar project on scurf of potatoes is being conducted at Fredericton and Ottawa.

Personnel from the Vineland Research Station and the Crop Loss Section at Ottawa surveyed 2,000 trees in 100 peach orchards in 1969 to assess the damage caused by peach canker which affects 98 trees out of every 100 in the Niagara peninsula. The survey was repeated in 1970 to determine the increase in disease from one year to the next.

The foliage diseases affecting the 350,000 acres of winter wheat in Ontario were assessed by survey in 1969 and 1970. The grain is worth approximately $25 million per annum and the losses due to mildew, leaf rust and spindle streak mosaic virus were estimated to cause losses totalling $1.25 million each year.

New techniques like aerial photography (see *Canada Agriculture*, Winter 1970 issue) are being used in the experimental and survey stage. Fig. 1 shows the development of late blight of potatoes in some plots. Differences in color attributable to disease can be measured and equated to the different levels of disease in experimental plots. If there is a consistent relationship between late blight as detected on infra red color film and the consequent losses in tuber yield this technique could be used as a survey tool to assess the decrease in tuber yield due to late blight in a farmer's field.

During the next few years it is hoped that Canadian scientists will make a major contribution to this aspect of plant pathology, by submitting proven assessments methods to F.A.O. who have agreed to arrange for world wide distribution of the information. The methods are contained in a loose leaf manual which F.A.O. will be distributing shortly and will serve to standardize methods of disease assessment in different countries. Currently, crop losses are being studied within the various disciplines but for the future the approach must be multi-disciplinary to account for the losses due to disease, pest, and other factors. The fusion of ideas from the different disciplines will not only help the research scientist, it will also mean that the agricultural industry will derive the maximum benefit from research. ■

CORN—KEY TO LIVESTOCK EXPANSION IN MANITOBA?

D.W. MacDONALD

La production de maïs hautement énergétique a, dans d'autres parties de l'Amérique du Nord, déclenché l'expansion de l'élevage dans les fermes autrefois réservées à la culture des céréales.

Dans l'est du Canada, zone limite de la culture du maïs, la production s'est accrue chaque année de 10% pour nourrir un cheptel toujours croissant. Les Manitobains se demandent si le maïs pourrait aussi chez eux participer au relèvement des exploitations affaiblies.

Expansion of beef cattle production has been—in most areas of North America—based on corn production. In Manitoba, where traditionally this expansion has been based on hay, pasture, and grain, any significant further increase will have to be based on a high-energy ration such as corn.

Manitobans have gone into cattle production based on hay and pasture in rotation with grains and special crops. But cattle production on cultivated hay and pasture programs hasn't increased to the same extent as production on more specialized feeding and management operations, or enterprises on less expensive range land.

Expansion of on-the-farm cattle enterprises have been triggered in other parts of the continent, on high-energy corn production. In eastern Canada, in so-called fringe areas for corn, there has been a 10 per cent annual increase in the crop largely to feed an expanding livestock population. Manitobans wonder if corn can do the same for them, providing a profitable alternative for depressed enterprises.

"With farmers showing more interest in corn," says Dr. W.N. MacNaughton, Director of the CDA Research Station, Brandon, Man., "we're taking a closer look at the crop. An important area of investigation is the moisture-heat balance of the climate in relation to maturity and yield of hybrids."

The author is with the CDA Information Division, Ottawa, Ont.

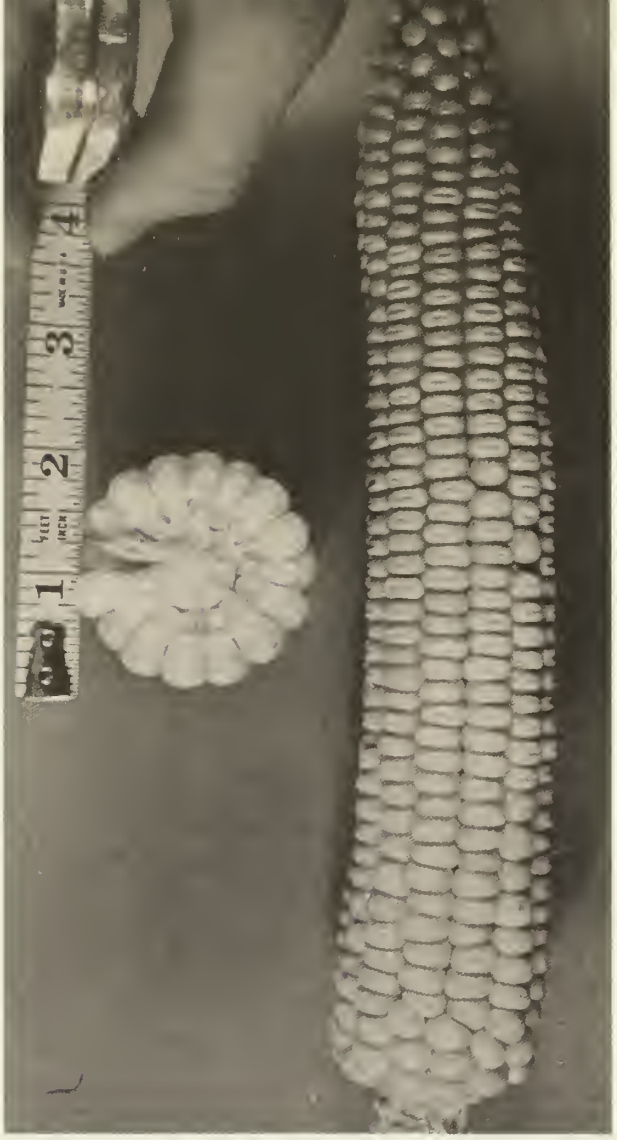
DISPELLING MYTHS

The man involved in finding answers to problems in corn production in western Manitoba is Dr. R.I. Hamilton, forage research officer at Brandon. He believes more information on the adaptability of the corn plant to Manitoba conditions is required, and certain myths about crop management will have to be dispelled before the crop is more generally accepted. But he is convinced that corn will become a more important factor in livestock production and has set up a comprehensive research program to prove it.

In southern Manitoba (Crop Districts 1 to 8), he points out, 5.1 million acres were planted to cereals or summerfallow in 1970. Nearly all of this area is suited to corn silage production, and a considerable acreage is satisfactory for grain corn as well, he observes. He sees a potential of 2 million acres of corn complemented with the other crops presently grown and no fallow. Two feeder steers will gain 500 lb each on one acre of corn silage. That means 4 million feeder calves for Manitoba, as well as the cows to raise them.

Data on corn production at Brandon goes back to 1888 when the experimental station first opened. Information on yield, date and planting and harvesting grain corn since 1933 is given in Table 1. Most striking perhaps is the increase in yield in recent years. Ninety-eight bushels per acre for the top five hybrids in 1970 probably reflects the potential of selecting new, earlier maturing hybrids, and the effects of fertilizer. It wasn't till 1967 that fertilizer was used on the corn variety trials.

Researchers at Brandon are investigating all factors to improve the potential for corn production in Manitoba.



Manitoba grown corn. Noted dented kernels, indicating maturity.

Mature kernels, chopped up with the rest of the plant, gives corn silage a remarkably high feed energy content.

HEAT UNITS

In eastern Canada, corn for silage is being successfully grown in areas having as few as 2,100 heat units. The accompanying heat unit map of Manitoba shows that the crop can't be ruled out on that factor. Hamilton draws attention to the fact that Dauphin, one hundred miles north of Brandon, can expect to accumulate 2,250 heat units during the growing season. The development of earlier hybrids would push the northern fringe of corn production towards the 1,900 heat unit line.

The Manitoba Corn Committee lists Morden 88 and Morden 67 as the earliest varieties suitable for the province. These double cross hybrids were developed by Dr. J. Giesbrecht at the CDA Research Station, Morden, Man., from flint and dent types. Flint provides early season growth and early physiological maturity believed necessary for the shorter Manitoba growing season.

Arranged in order of earliness, other hybrids, largely of the dent type recommended for silage in Manitoba, are: Pride R101, Stewarts 2605, Pride 116, Pride 109, Warwick S.L. 209, N.K. PX417 and Dekalb 22. Only the earliest hybrids should be considered for grain.

Western Manitoba soils tend to be dry, and a dry soil helps compensate for fewer heat units. Dry soils warm up earlier, allowing for early seeding and growth of the crop during the long daylight hours of spring.

Rainfall at Brandon is usually adequate for corn production. It is low during March and April (1 to 1.1 inches per month) giving the soil a chance to dry out. Average rainfall is 2 inches in May and 3.5 in June when the crop can use it. With 2.9 inches in July and 2.6 in August, the crop usually gets by without irrigation. Rainfall tends to drop off in September to allow for harvest.

DRYING WINDS

Severe wilting, due to hot drying winds, can be a serious problem with corn in semi-arid areas. In western Manitoba there's normally more moisture in the air than areas to the west where burning of the leaves occurs, even under irrigation conditions. Higher plant populations are possible under humid conditions and Hamilton expects the range to be between 20 and 30 thousand plants per acre in Manitoba. The higher rates are normally used for silage. It's advisable to sow about 10 per cent above the rate for the population desired.

Corn would give Manitobans an opportunity to clean up weeds. Atrazine has been effective but the susceptibility of certain crops to atrazine residues the year following normal application precludes its general use. Rather, atrazine is recommended at a reduced rate (1 lb active) in combination with 3 lb

Sutan for control of annual broadleaf and grassy weeds, as well as perennials such as Canada thistle and quackgrass. Weed control recommendations are reviewed annually and published each spring by uhe Manitoba Department of Agriculture.

Early maturity in hybrids is essential for high dry matter yields at harvest. The accompanying table shows the build-up of a dry matter as the crop matures, reaching an optimum on October 6 in this 1969 crop test. Anything under 70 per cent dry matter is satisfactory according to Dr. Hamilton. However, western corn growers have been known to harvest their corn right after the grain harvest in early September to avoid frost. Research shows that present hybrids may not have matured sufficiently by that time and consequently silage has generally been poor quality, with losses through seepage and freezing.

MATURITY MOST IMPORTANT

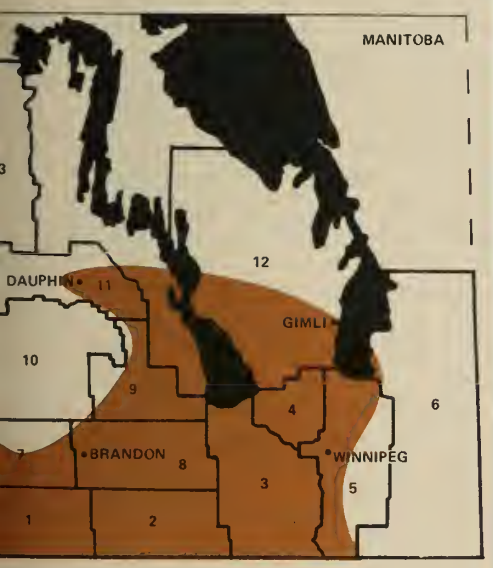
A crop touched by early frost will often continue to mature and increase in feed value. Dr. Hamilton believes there is more to be gained by delaying harvesting till the minimum dry matter level (70 per cent) is reached rather than harvesting prematurely to avoid frost. Losses from immature silage can be more serious than losses from light frost.

Corn is a heavier feeder than most other crops grown in Manitoba. A hundred bushel corn crop removes about 157 pounds of nitrogen, 27 pounds of phosphorus and 102 pounds of potash. This must be returned to the soil in the form of fertilizer where natural fertility is inadequate, if profitable yields are to be maintained. Using soil test information, researchers at Brandon have been able to accurately estimate the amount of nitrogen, phosphorus and potassium required. At Brandon, all of the phosphorus and potassium is applied at or before seeding, while nitrogen is split, half being applied before seeding and the remainder banded when the standing leaf height of the corn is 8 to 12 inches.

A major consideration in better management of the corn crop in western Manitoba is earlier planting. Plant as soon as the land is ready, Hamilton advises, preferably by May 15. He has seeded corn before the end of April. It has survived cold weather and germinated four weeks later when the soil warmed up. The growing tip of the corn plant does not emerge above ground until five weeks after germination. It's protected against frost till well on in June when the danger of severe frost is over. Leaves that emerge first following germination may be affected by frost but as long as the growing tip is not damaged the crop will recover quickly on the established root system.

Manitoba has been known to experience frost in every month of the year. At Brandon, the corn crop has been killed back by frost as late as June 20, in 1968, but there has been no crop failure. A yield of 78 bushels per acre was recorded on corn plots that recovered from four frost periods in June 1968, the latest being 25°F on June 20.

There are problems with corn in Manitoba but with some scientific investigation a new pattern may emerge which will make it the most reliable and convenient crop for on-the-farm cattle producers. ■



ntial corn producing area in southern Manitoba is ked by line showing more or less than 2100 heat units. phin, Gimli, Brandon and Winnipeg all register more 2100 units.

TABLE 1. GRAIN CORN VARIETY TRIALS, BRANDON RESEARCH STATION, 1933-1969

	Grain (bu/acre) all varieties	Top 5	Date at planting	Date of harvest	Length of growing season
1933-39	35	48	May 10	Sept. 14	127
1940-49	58	67	15	24	131
1950-59	44	51	24	Oct. 5	133
1960-69	47	59	24	Sept. 23	121
1970	78	98	25	Sept. 29	126

TABLE 2. EFFECT OF FALL HARVEST DATE ON YIELD OF DRY MATTER, BRANDON RESEARCH STATION, 1969

	Harvest date				
	Aug. 14	Sept. 2	Sept. 24	Oct. 6	Oct. 20
Yield (tons dry matter/acre)	1.6	3.4	4.7	5.7	4.8
% dry matter (whole plant)	89	82	71	62	

PESTICIDES IN OUR ENVIRONMENT

PESTICIDES ET MILIEU AMBIANT

Since DDT was developed during the second world war chemical companies have been producing a steady flow of new pesticides. Before any of these compounds can go on the market a great deal of research must be done by the chemical companies, universities and government research laboratories.

Depuis que le DDT a été découvert au cours de la deuxième guerre mondiale, les manufacturiers de produits chimiques ont créé constamment de nouveaux pesticides. Avant qu'un de ces produits puisse être offert sur le marché, il faut que beaucoup de recherches soient faites par les fabricants de produits chimiques, les universités et les laboratoires de recherche du gouvernement.

J. G. SAHA

In the current concern over the pollution of our environment it is natural for some Canadians to think that our air, water, food, land, and wild life are poisoned with residues of pesticides. Many people are confused about the extent and significance of this pollution problem.

The pesticide DDT was once hailed as a gift from God to save mankind from some of the diseases that plagued us and to protect our food from devastation by insects. The discoverer of DDT, Dr. Paul Müller, was given the highest honor—the Nobel Prize. Only a few decades later some people are accusing DDT of causing untold harm to the environment.

This change in attitude towards DDT and other organochlorine pesticides has resulted from the vast amount of research that has been carried out during the past two decades into the behavior, efficacy, chemistry, metabolism, and disappearance of pesticides. These studies have been due to almost unbelievable advances in pesticide residue analysis. It is now possible to detect organochlorine pesticides in concentrations as low as a few parts per trillion. One part per trillion is equivalent to the astronomical ratio of 1 inch in 15,780,000 miles! Calculated similarly 1 part per million is 1 inch in 15.7 miles! Both the ratios demonstrate the almost inconceivably low levels of pesticide detection that can now be attained with modern methods.

As a consequence of these highly sophisticated methods of analysis we are discovering new problems associated with the use of pesticides. It is now evident

Dr. Saha specializes in pesticide chemistry at the CDA Research Station, Saskatoon, Sask.

J. G. SAHA

Le courant d'inquiétude suscité par la publicité sur la pollution laisse croire, que l'air, l'eau, les aliments, le sol et la faune sont empoisonnés par des résidus de pesticides. La confusion est grande au sujet de l'étendue et de l'importance de cette pollution.

Naguère, le DDT fut accueilli comme un don du Ciel. Le découvreur du DDT, le Dr Paul Müller, a reçu le plus grand honneur qui puisse être offert à un savant, le prix Nobel. Quelques décennies plus tard, des gens accusent le DDT de causer des torts inestimables au milieu ambiant.

Ce changement d'attitude à l'égard du DDT, et d'autres pesticides organochlorés a engendré de nombreuses recherches au cours des deux dernières décennies sur le comportement, l'efficacité, les caractères chimiques, le métabolisme et la désintégration des pesticides. Ces études ne furent possibles que grâce à des progrès incroyables dans l'analyse des résidus. Il est possible aujourd'hui de dépister les pesticides organochlorés en concentrations aussi infimes que quelques parties par trillion. Une partie par trillion est l'équivalent du rapport astronomique d'un pouce à raison de 15,780,000 milles. Par analogie une partie par million équivaudrait à 1 pouce pour 15.7 milles. Ces deux rapports démontrent les niveaux incroyablement bas auxquels peut se faire maintenant la détection grâce aux méthodes modernes.

Grâce à ces méthodes d'analyse très perfectionnées nous découvrons de nouveaux problèmes découlant de l'utilisation des pesticides. On découvre aujourd'hui que les organochlorés persistent et finissent par

Le Dr Saha se spécialise dans la chimie des pesticides à la Station de recherches du ministère de l'Agriculture du Canada à Saskatoon, (Sask.).

that the organochlorine pesticides are persisting in the environment and finding their way to areas far removed from the site of application. We are now finding DDT in extremely low amounts almost everywhere. It is also evident now that because of biological magnification animals at the top of the food chain can accumulate these pesticides in concentrations that may be harmful to some species.

The Canada Department of Agriculture is responsible for registering all pesticides used in this country. The decision to register a pesticide is based on the best available scientific information on risk and benefits. Much of this information comes from the Research Branch of the Department which has many laboratories where the behavior of pesticides in the environment is studied in depth. It was scientists in the Research Branch who first demonstrated that the insecticide dieldrin can persist in soil as much as nine years after application. The Saskatoon Research Station is one of the many locations where the behavior of pesticides is studied. A brief review of the work done in this laboratory will illustrate some of scientific investigations carried out by the Department aimed at to keeping environmental pollution from pesticides to a minimum.

Development of sensitive and reliable methods for the determination of pesticide residues is very important in any studies involving pesticides. The laboratory at Saskatoon has developed methods whereby a few parts per billion of organochlorine pesticides in plants, soils, and other biological material can be detected and accurately determined. The high sensitivity of these methods, developed here and elsewhere, has contributed to consumer safety. The older methods of analysis, for example, were not sensitive below 1 part per million of DDT, DDE, and DDD residues in milk. But modern chromatographic methods can detect much lower concentration of these residues. Consequently the 'actionable level' for DDT residues is now only 0.05 p.p.m. in milk. Thus the level of DDT in milk that was regarded safe for human consumption a few years ago could now be considered unsafe and use-patterns have been modified to keep residue levels within acceptable limits.

Experiments carried out in the field have shown that wheat grain grown in soils treated with high levels of persistent organochlorine pesticides, like aldrin, dieldrin and endrin do not contain any residues detectable by these highly sensitive methods. In other studies cereal grains grown from seeds treated with organochlorine pesticides were also found to have no detectable residue. Yet another study showed that cereal crops grown from seeds treated with organomercury seed dressings did not contain any more mercury than those grown from untreated seeds. Thus game birds could not become contaminated with mercury from feeding on harvested grains

atteindre même des endroits très éloignés de celui où on les a appliqués. On apprend aussi qu'en raison de l'amplification biologique, les animaux qui occupent le sommet de la chaîne alimentaire peuvent accumuler ces pesticides à des concentrations dangereuses pour certaines espèces.

Le ministère de l'Agriculture du Canada est chargé de l'homologation de tous les pesticides utilisés au pays. L'admission à l'homologation d'un pesticide repose sur les meilleurs renseignements scientifiques disponibles quant aux risques et aux avantages. Une bonne partie de cette information provient des nombreux laboratoires de la Direction de la recherche du Ministère où l'on étudie en profondeur les effets des pesticides sur le milieu. Ce sont les chercheurs de la Direction qui ont été les premiers à démontrer que l'insecticide Dieldrine peut persister dans le sol jusqu'à neuf ans après son application. La Station de recherches de Saskatoon est l'un des nombreux endroits où l'on étudie les effets rémanents des pesticides. Une brève revue du travail fait à ce laboratoire fera connaître quelques-unes des recherches scientifiques entreprises par le Ministère en vue de réduire au minimum la pollution.

Dans toutes les études se rapportant aux pesticides, la mise au point de méthodes sûres et précises pour déterminer leurs résidus est chose très importante. Le laboratoire de Saskatoon a mis au point des méthodes assez sensibles pour déceler la présence de quelques parties par million de pesticides organochlorés et autres produits biologiques dans les plantes et les sols. La très grande sensibilité de ces méthodes mises au point ici et ailleurs a contribué à la sécurité des consommateurs. Les anciennes méthodes d'analyses, par exemple, ne permettaient pas de dépister des quantités inférieures à une partie par million de DDT, DDE et DDD dans le lait. En revanche, les méthodes chromatographiques modernes permettent de retracer des concentrations beaucoup plus faibles de ces résidus. En conséquence, le "niveau d'intervention" pour les résidus du DDT a maintenant été réduit à 0.05 p.p.m. dans le lait. Ainsi, le niveau de DDT du lait que l'on considérait inoffensif il y a quelques années est aujourd'hui jugé dangereux et les méthodes d'emploi ont été modifiées pour maintenir le niveau des résidus dans des limites acceptables.

Des expériences faites en plein champ ont démontré que le blé récolté dans des sols traités avec de fortes quantités d'organochlorés persistants, comme l'aldrine, la dieldrine et l'endrine, ne contient aucun résidu décelable par ces méthodes très sensibles. Au cours d'autres études faites sur les grains des céréales provenant de semences traitées avec des organochlorés, on n'a encore trouvé aucune trace de résidus. Une autre expérience a démontré que les récoltes de céréales provenant de semences traitées avec des organomercurés ne contenaient pas plus de mercure que celles qui provenaient de semences non traitées.

The chemist's gas chromatograph makes possible the accurate determination of pesticides at levels as low as parts per million or trillion.

left in the field. They could, however, become contaminated from feeding on treated seeds left uncovered by soil in the field at the seeding time or treated seeds discarded in garbage dumps or elsewhere. Mercury has a rather short half-life in the animal body. Although game birds may have significant mercury residue in the spring, this level should decrease considerably in the fall. We have actually observed this happening. These studies have shown that Canada's most important agricultural product, wheat, is free from pesticides used for its production. In depth studies are also carried out on the factors affecting the persistence of these pesticides in plants and soils.

The factors affecting the absorption of pesticide residues by crops grown in contaminated soil are also studied. These studies have shown that root crops absorb more residues than oil seed crops which, in turn absorb more residues than forage crops. Cereal crops have the least tendency to absorb pesticide residues from contaminated soil. Thus it may not be safe to grow carrots in a particular contaminated soil but it may be quite safe to grow cereal or other types of crops. This kind of study provides information for advising farmers as to what type of crop they could grow in soil contaminated with persistent organochlorine pesticides so that the crops would not contain harmful residues.

Degradation of pesticides by soils and plants is an important area for research. In many cases the pesticide is degraded to less toxic products but in some cases it can be converted into more toxic products. Heptachlor and aldrin, for example, are converted by plants, soils and animals into more toxic heptachlor epoxide and dieldrin, respectively. Studies carried out at Saskatoon have shown that dieldrin is not degraded by plants and soils whereas lindane is broken down into less toxic products. This type of study gives us a better understanding of the persistence of the compound in the environment. If it is not biodegradable and the compound has low volatility it would persist in the environment for a long time as is the case with dieldrin. Conversely chemicals that

En utilisant la chromatographie en phase gazeuse, le chimiste peut déterminer avec exactitude la concentration des pesticides à des niveaux aussi faibles que les millionièmes ou les trillionièmes.

Le gibier à plume ne peut donc pas se contaminer avec du mercure provenant de grains laissés sur les champs après la récolte. Ils peuvent toutefois se contaminer en mangeant des semences traitées non enfouies dans le sol ou jetées au dépotoir et ailleurs. Le mercure conserve une demi-vie plutôt courte dans le corps de l'animal. Par conséquent bien que le gibier à plume puisse contenir des résidus mercuriels en quantité assez forte au printemps, ce niveau devrait baisser considérablement à l'automne. C'est en effet ce qui a été constaté. Les expériences ont démontré que le produit agricole le plus important du Canada, le blé, est exempt des pesticides utilisés pour sa production. Des études approfondies sont aussi menées sur les facteurs qui influent sur la rémanence de ces pesticides dans les plantes et le sol.

On étudie aussi les facteurs qui influent sur l'absorption des résidus de pesticide par les récoltes cultivées en sol contaminé. On a pu constater que les plantes-racines absorbent plus de résidus que les oléagineux qui, à leur tour, en absorbent plus que les récoltes fourragères. Les céréales sont moins portées à absorber les résidus de pesticide des sols contaminés. Il pourrait donc n'être pas sûr de cultiver des carottes sur un sol particulièrement contaminé, mais on pourrait y pratiquer la culture de céréales ou d'autres sortes de plantes. Ce genre d'études fournit des renseignements utiles pour conseiller les cultivateurs sur la sorte de culture à produire en sol contaminé par des organochlorés pour que leurs récoltes ne contiennent pas de résidus dangereux.

La dégradation des pesticides par les sols et les plantes est un important domaine des recherches. En certains cas, le pesticide se dégrade en produits moins toxiques, mais en certains autres cas il peut se transformer en d'autres produits encore plus toxiques. Ainsi, l'heptachlore et l'aldrine sont transformés par les plantes, les sols et les animaux en produits encore plus toxiques, soit en époxyde d'heptachlore et en dieldrine respectivement. Des études faites à Saskatoon ont démontré que la dieldrine n'est pas dégradée par les plantes et les sols, tandis que le lindane se dégrade en produits moins toxiques. Ce genre d'études nous donne une meilleure compréhension de la rémanence d'un produit. Lorsqu'il n'est pas dégradable et que sa volatilité est faible, il persiste longtemps comme c'est le cas pour la dieldrine. En revanche, les produits chimiques qui sont facilement dégradables n'ont qu'une courte durée et sont rapidement éliminés du corps de l'animal auquel ils causent par conséquent peu de dommages. La plupart des carbamates et organophosphorés les plus récents possèdent cette caractéristique très recherchée.

On s'est beaucoup préoccupé du contrôle des résidus de pesticide. On a analysé dans ce labora-

are easily biodegradable would have a short life in the environment and would be eliminated from the animal body quickly, causing little or no harm. Most of the newer organophosphorus and carbamates have this highly desirable characteristic.

Much effort has been given to the monitoring of the environment for pesticide residues. Hundreds of fish, soil, and crop samples from various parts of Saskatchewan have been analyzed in this laboratory. Although many of these samples contained less than 1/10th of a part per million residues, there has never been a case where the food contained residues in excess of the permissible amount. The theoretical daily intake of pesticide residues is calculated on the assumption that every food we eat is contaminated at the highest permissible level. For example the tolerance for DDT of most fruits and vegetables is 1 p.p.m. except for apples, pears and celery which is 3.5 p.p.m., and meat products (based on fat) is 7 p.p.m. The theoretical daily intake of DDT is calculated on the assumption that all fruit, vegetable and meat are contaminated with 7 p.p.m. of DDT. The analyses of thousands of food and animal feed samples over the years by many laboratories in this country have shown that only about 2 percent of all food and animal feed has significant amounts of DDT. Contamination of food with 7 p.p.m. or more of DDT has been rarely encountered. The acceptable daily intake is about 1/100th of the amount that is considered to be safe from experiments with sensitive animals. In addition to the 100-fold safety factor in the setting up of acceptable daily intake and tolerance levels the consumer has two other safety factors of similar importance. Firstly, only a small fraction of the food is contaminated. Secondly, most of the residues present in the raw food are removed during the preparation of the meal. Experiments carried out in this laboratory have shown that home processing techniques like washing, peeling, and boiling remove more than 90 percent of the residues present in root crops. Commercial processing of vegetable oil removes nearly all the residues present in the raw oil. Thus we are actually consuming only a fraction of the residues contained in the raw food.

Although there may be no direct hazard to human health from the low level contamination of our environment with pesticide residues, some of these chemicals may be causing harm to some species of wild life and fish.

As research into the behavior of pesticides revealed these possible harmful effects of the persistent pesticides, the Department of Agriculture took steps to reduce their use drastically. The organochlorine insecticides are now being replaced by the less persistent and biodegradable organophosphorus and carbamate insecticides. It is through continued research that we will know more about the behaviour of pesticides in our environment. ■

toire des centaines d'échantillons de poissons, de sols et de récoltes venant de diverses parties de la Saskatchewan. Même si beaucoup d'entre eux contenaient moins de 1/10 de partie par million de résidus, on n'a pas rencontré un seul cas où les aliments contenaient plus de résidus que la tolérance prévue. Théoriquement, l'ingestion quotidienne de résidus est calculée en présumant que tout aliment consommé est contaminé au niveau maximal permis. Ainsi, la tolérance fixée pour le DDT à l'égard de la plupart des fruits et légumes est de 1 p.p.m. excepté pour ce qui est des pommes, des poires et du céleri, dont le niveau a été fixé à 3.5 p.p.m.; pour les produits de la viande, ce niveau (fondé sur le gras) est de 7 p.p.m. Théoriquement, l'ingestion quotidienne de DDT est calculée en présumant que tous les fruits, légumes et viandes sont contaminés avec 7 p.p.m. de DDT. Au cours des années, l'analyse de milliers d'échantillons d'aliments de l'homme et des animaux, faite par de nombreux laboratoires du pays a démontré que seulement à peu près 2% de tous les aliments des deux groupes contiennent des quantités notables de DDT. On a rarement rencontré des aliments contaminés à 7 p.p.m. ou plus de DDT. L'ingestion quotidienne acceptable est d'environ 1/100 de la quantité considérée comme sans danger suivant des expériences faites avec des animaux sensibles. En plus d'un facteur de sécurité centuplé en ce qui a trait aux niveaux établis pour l'ingestion quotidienne et la tolérance, le consommateur dispose de deux autres facteurs de sécurité d'importance semblable. D'abord, seulement une faible partie de l'aliment se trouve contaminée. Ensuite, la plupart des résidus contenus dans l'aliment cru sont éliminés au cours de la préparation du repas. Des expériences faites à ce laboratoire ont démontré que la préparation comme le lavage, l'épluchage et l'ébullition enlèvent plus de 90% des résidus contenus dans les plantes racines. Le traitement des huiles pour la production commerciale d'huiles végétales fait disparaître presque tous les résidus contenus dans l'huile brute. Nous ne consommons donc qu'une fraction des résidus que renferment les aliments crus.

Même si la santé de l'homme n'est pas exposée à des dangers en raison du bas niveau de contamination par des résidus de pesticides, certains de ces produits chimiques peuvent causer des dommages à quelques espèces d'animaux sauvages et de poissons.

Comme les recherches sur les effets rémanents des pesticides ont révélé la possibilité d'effets dangereux de la part de pesticides persistants, le ministère de l'Agriculture a pris des mesures pour réduire considérablement leur utilisation. Les organochlorés sont maintenant remplacés par des carbamates et des organophosphorés qui sont moins persistants et sont dégradables. C'est grâce à des recherches soutenues que nous nous renseignerons davantage sur les effets des pesticides sur notre milieu ambiant. ■

INTERNATIONAL HYDROLOGICAL DECADE . . .

IHD promotes international cooperation in studies on management of fresh water

W. S. FERGUSON

Le Canada est un participant actif à la Décennie hydrologique internationale, (1965-1974), patronnée par l'UNESCO dans le but d'encourager la participation internationale aux études et à la compilation des connaissances sur les méthodes de gestion des eaux douces.

Water is undoubtedly one of the most important natural resources of any country. It is a resource which requires a high degree of intelligent and cooperative management. There are several reasons for this:

- The supply of water is extremely variable both in time and space. A very large proportion of man's ingenuity has been devoted to means of modifying the distribution of water to better serve his needs.
- Water is a multiple use resource and the different users frequently have conflicting or competing requirements for water.
- Water is an important part of the natural environment and altering its quality or its distribution in time or space can cause major changes in the natural environment. These changes may be beneficial or detrimental and at our present state of knowledge they are not always predictable.
- Much of the world's fresh water supply is international which further complicates management decisions.

The United Nations Educational Scientific and Cultural Organization (UNESCO) is the sponsor of the International Hydrological Decade (IHD) 1965-1974. The major reason for designating IHD was to encourage international cooperative scientific studies and information exchange to improve and disseminate the knowledge required for best management of fresh water. Canada has been cooperating in this international program and a number of federal and provincial government departments and universities are conducting research projects under the auspices of the IHD. The objectives of the IHD are very broad, covering such things as total fresh water supply, its distribution in time and space, the effects of water storage on climatic factors, the sedimentation of streams, water quality and the more general social and economic consequences of man's activities on the hydrological cycle. However, it will also be of specific value to the Canadian agricultural industry.

The study of small watersheds is of particular interest to agriculture. Approximately 50 small watersheds from British Columbia to Nova Scotia are instrumented to measure their hydrological parameters. These studies will provide information on

Dr. Ferguson is Research Coordinator (Soil Fertility), CDA Research Branch, Ottawa, Ont.

such things as the factors which influence runoff from rain and snowmelt or conversely how to increase soil moisture storage, factors effecting soil erosion, water losses from storage basins by evaporation and percolation, and the effect of soil and vegetation manipulation on the quantity and quality of water in small basins.

Studies of groundwater also have great potential value to agriculture. It is well known that very large quantities of water are present in underground aquifers. However, information is lacking on the extent and locations of these aquifers, the quality of the water, the rates of recharge of the aquifers and the most efficient methods of utilization of the water. A substantial portion of the IHD program is designed to fill these gaps in our knowledge.

The program also includes studies on irrigation practices with particular reference to water use efficiency and drainage problems. Such things as the effect of irrigation on crop growth, evapotranspiration and air temperatures are being studied. Particular emphasis is being put on the effect of drainage water from irrigation projects on salinity of soils and streams and the effect of these practices on the quality of water for downstream users.

Admittedly a good deal of this research would be conducted without the auspices of the IHD. However, the IHD provides a national and international forum for the cooperative collection and collation of hydrological data. this adds greatly to the value of all investigations conducted because the information collected is available to a large number of agencies. In addition, it emphasizes the multiple use characteristic of water, reminding all users of their responsibility to society for maintaining the quality of a valuable natural resource.

Knowledge is the only certain way of taking some of the heat out of the current debate on water pollution and allowing us to intelligently manage our water resources. The program being conducted under the auspices of the IHD will provide some of this badly needed knowledge. ■

The amount of spring runoff is important information for agriculture, for flood control agencies and for many other segments of society concerned with water supply and utilization. The above photograph shows a device which records the amount of runoff from a 3,000-acre watershed near Davin, Saskatchewan.

Water evapotranspiration from growing crops is a very important part of the hydrological cycle. Mr. Korven, an agricultural engineer at the Canada Department of Agriculture Research Station, Swift Current, Saskatchewan, points to the location of a buried device which is used to measure the rate of water loss from the soil to the atmosphere. In this study comparisons of irrigated and dry-land crops are made.

SOILLESS CULTURE FOR GREENHOUSE TOMATOES

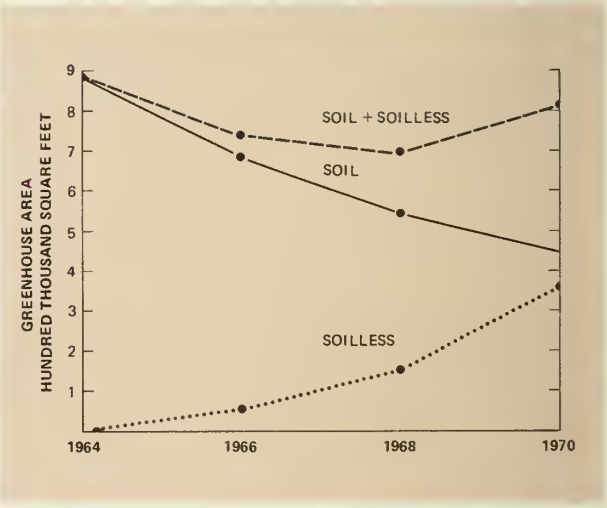
R. M. ADAMSON and E. F. MAAS

Grâce à la réalisation commerciale des recherches sur les éléments nutritifs en solution pour la culture hydroponique des tomates en serre, une entreprise de l'Ile de Vancouver connaît un renouveau. Ces systèmes, automatiques, réduisent les frais de main-d'œuvre et éliminent du même coup les maladies du sol et les parasites, ce qui augmente le rendement.

Eight years ago the once prosperous greenhouse tomato industry of Vancouver Island was in danger of coming apart at the seams. Growers were beset with a formidable combination of low yields, sharply rising costs and increasing competition from Californian imports on both their local and Prairie markets. Improvement resulting from better cultural practices and new varieties scarcely kept pace with increasing losses from soil borne pests and diseases and soil deterioration. Money was no longer available for adequate greenhouse repairs and maintenance and those lost to collapse or urban encroachment were not replaced.

Experiments on the improvement of "problem" greenhouse soils with peat, sand, sawdust and straw conducted at the Saanichton Research Station in 1962 and 1963 and in a commercial greenhouse in 1963 and 1964 failed to increase yields appreciably. At the same time experiments with nutrient solution culture of tomatoes in beds of sand, sawdust and peat gave encouraging results. Nutrient solutions based on Hoagland's formula were modified to suit our conditions of marginal natural light and nutrient solution distribution systems were developed. By this method plants are supplied, usually twice daily, with a nutrient solution either from a dilute solution storage tank or a diluter. The solution is distributed to individual

Mr. Adamson is vegetable crop specialist and Mr. Maas is a plant nutritionist at CDA Research Station, Saanichton, B.C.



Although soil culture of greenhouse tomato production has continued to decline on Vancouver Island the total area has risen during the last two years due to the sharp increase of the soilless method.

Top—Profitable returns from growing tomatoes by soilless culture with automated nutrient solution feeding have initiated a new expansion of the greenhouse industry.

Bottom—A fall crop of tomatoes in plastic bags of soilless media were given an early start outdoors and then brought into the greenhouse to follow a spring greenhouse crop.

plants by fine bore plastic tubes inserted into rigid plastic hose headers located between each double row of plants.

In 1965, in cooperation with the B. C. Department of Agriculture we grew 500 tomato plants in a 3:1 sand-sawdust mixture with nutrient solutions in a commercial greenhouse. The yield on this plot was twice as great as from a similar number of soil-grown plants in the same greenhouse. Based on these results and experiments at the Research Station, four commercial growers tried soilless culture in 1966, three with sawdust and one with a sand-sawdust mixture. Yields and fruit size were remarkably good and the feeding system reduced the labor requirement by half. In the following years more commercial growers adopted the soilless method but found sawdust more convenient to use than the mixture of sand and sawdust. By 1968 a building boom of new greenhouse construction was under way, all using sawdust as the rooting medium and equipped with nutrient solution distribution systems. This surge of greenhouse building is still continuing but as a result of our research and grower innovation many modifications are appearing in the industry. Across-the-house sawdust beds on plastic film to isolate them from contaminated soil below have been replaced by curbed beds. In 1969 a method of growing the plants in perforated polyethylene bags on plastic sheeting caught the attention of the growers and by 1970 sawdust in bags was adopted by several. These bags contain up to five gallons of medium and support one, two or three plants. Peat and peat-sand mixtures were also tried in these bags but cost of the peat and difficulty in handling mixtures containing sand may limit their use. Two gallon plastic pots for sawdust and peat-sand mixtures are also being tried.

Dilute nutrient solutions in large mixing tanks have almost completely replaced diluters. The premixing of phosphate, dolomitic limestone and the minor elements into the planting medium has increased yields and simplified nutrient solution feeding. Spring crops on sawdust are yielding up to 10 pounds per plant on a spacing of 3 sq ft/plant, double the average yields by the earlier soil-grown method. Fall crops are being planted earlier, especially where the plants are grown in polyethylene bags outdoors during mid-summer. These are moved into the greenhouse as soon as the spring crop has been removed.

The quality of local midsummer greenhouse tomatoes has improved to the point where they are competing successfully with California imports and Okanagan field-grown tomatoes and command a premium price. Part time operators have found a summer crop economical to grow by this system in their unheated greenhouses.

Research is continuing along lines affecting both soil and soilless culture. Many of the techniques developed for soilless culture can be used equally well for soil culture. A recommendation to use sawdust or some other soilless medium is made only if suitable soil is not available. The almost complete devotion of new greenhouse tomato space to soilless media, however indicates the confidence of the growers in its value. For this system the selection of the greenhouse site is no longer restricted to the limited soil areas suitable for tomato production. Sites can now be selected on the basis of local microclimates of favorable temperatures, hours of sunshine and wind protection as well as convenience to water supplies or expansion of an existing farm enterprise. ■

CANADA
AGRICULTURE